PB-250 155

DISASTER ASSISTANCE - EARTHQUAKE HAZARD REDUCTION. VOLUME 1.

NATO Committee on the Challenges of Modern Society
Brussels, Belgium

May 1971

DISTRIBUTED BY:

NTIS
National Technical Information Service
U. S. DEPARTMENT OF COMMERCE

PB 250 155

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
US Department of Commerce
Springfield, VA. 22151

BIBLIOGRAPHIC DATA SHEET

1. Report No.

2.

3. Recipient's Accession No.

4. Title and Subtitle

Disaster Assistance - Earthquake Hazard Reduction

5. Report Date
May, 1971

6.

7. Author(s)

8. Performing Organization Rept. No. Vol. 1 No. 9

9. Performing Organization Name and Address
Committee on the Challenges of Modern Society
NATO

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstracts

This report deals with the areas of: hazard evaluation; building codes and other hazard reduction techniques; economic and legislative aspects of hazard reduction techniques; land use planning; and disaster and education information programmes.

17. Key Words and Document Analysis. 17a. Descriptors

Earthquake disaster
Earthquake hazard reduction

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

PRICES SUBJECT TO CHANGE

18. Availability Statement

19. Security Class (This Report)
UNCLASSIFIED

20. Security Class (This Page)
UNCLASSIFIED

21. No. of Pages
302

22. Price
$9.75

DISASTER ASSISTANCE

Earthquake Hazard Reduction

N.9

SECOURS EN CAS DE DESASTRES NATURELS

Tremblements de terre

Vol. 1

1(2)

Mr. Carlo Calenda (Italy)

"Our meeting has been a forum for wide ranging encounters devoted to the study of problems of the deepest interest.

I believe that from the exchange of views about the different techniques related to the prevention of earthquakes and the organization of relief operations many extremely fruitful result have been obtained.

It is now up to each country and to the International Organizations to put into action the suggestions made in San Francisco, for a better and more serene life for the world community."

Carlo Calenda

"The widespread interest in this NATO-originated effort has brought new dimensions to CCMS activities, the recognition that natural disasters transcend all boundaries, and a strengthened spirit of cooperation among nations."

Darrell M. Trent

Mr. Darrel M. Trent (U.S.A.)

Mr. Lee A. DuBridge (U.S.A.)

> *"Earthquake disasters are a continual threat to many nations of the world. May the Proceedings herein reproduced be a guide and inspiration to all those who seek to minimize the cost in human suffering caused by such events."*

Lee A. DuBridge

"The meeting on Earthquakes has been very useful and as a result many practical recommendations were put forward. It is now up to all of us to work together to minimize the effect of earthquakes and to protect people against this natural disaster."

Kazim Ergin

Mr. Kazim Ergin (Turkey)

TABLE OF CONTENTS

Pages

1. Report on the International Meeting on Earthquakes as approved by the Committee on the Challenges of Modern Society and by the North Atlantic Council 1- 38

Rapport sur la réunion internationale sur les séismes, approuvé par le Comité sur les Défis de la Société Moderne et par le Conseil de l'Atlantique Nord

2. Agenda of the Meeting 39- 40

Ordre du jour de la réunion

3. Addresses by : Dr. Lee A. Dubridge 41- 45
Déclarations de : Dr. Gunnar Randers 46- 49
Dr. Charles F. Richter 50- 52
Hon. Carlo Calenda 53- 58
Hon. Darrell M. Trent 59- 61
Dr. Kazim Ergin 62- 63
Hon. John A. Volpe 64- 69
Mrs. Shirley Temple Black 70- 76
Hon. Rogers G.B. Morton 77- 79
Hon. G.A. Lincoln 80- 84

4. List of participants to the Meeting 85-103

Liste des participants à la réunion

5. Agenda and list of participants to Working Group I 104-109

Ordre du jour et participants au Groupe de travail I

6. Agenda and list of participants to Working Group II 110-112

Ordre du jour et participants au Groupe de travail II

Statement by Dr. Migliore 113-116
Déclaration du Dr. Migliore
Priority Action/Mesures prioritaires 117
Presentation by Dr. Schaefer 118-119
Déclaration du Dr. Schaefer
Statement by Mr. C. Bay Rossi 120-122
Déclaration de M. C. Bay Rossi
Guidance for a Preparedness Programme 123-124
Directives pour un programme de préparation

7. Agenda and list of participants to Working Group III 125-126

Ordre du jour et participants au Groupe de travail III

Pages

8. Agenda and list of participants to Working Group IV 127-128

Ordre du jour et participants au Groupe de travail IV

Report by the Chairman/Rapport du Président 129-132
Issues for Discussion/Points de discussion 133-134

9. List of Conference documents 135-140

Liste des documents distribués à la réunion

10. Conference documents (*) 1.1- 68

Documents

---

* In view of the very voluminous quantity of documentation made available at the meeting summaries only are given in a number of cases in order that the present volume may be kept to a manageable size.

* Compte tenu du volume des documents disponibles à la réunion, seuls des résumés ont été fournis dans un certain nombre de cas de manière à garder une taille raisonnable à la présente publication.

DISASTER PROGRAMME

Report on the International Meeting on Earthquakes held in San Francisco (United States) on 20th to 25th May, 1971

I. Introduction

A. About 170 seismologists, scientists, engineers, urban planners, disaster experts and public officials from around the world met in San Francisco on 20th to 25th May, 1971, to exchange information on earthquake related problems and to formulate practical recommendations for reducing earthquake hazards and for mitigating the effects of major earthquakes. The meeting was part of a comprehensive project on disaster assistance which is being conducted jointly by the Governments of Italy, Turkey and the United States for the NATO Committee on the Challenges of Modern Society (CCMS).

B. In addition to representation from eight NATO countries (Canada, Denmark, the Federal Republic of Germany, Greece, Italy, Portugal, Turkey and the United States), there were a large number of participants from non-NATO nations: Bolivia, Chile, the Republic of China, Mexico, New Zealand, the Philippines, Peru, Spain and Venezuela. Representatives also attended from the United Nations, European Earthquake Engineering Commission, European Seismological Commission, International Association of Seismology and Physics of the Earth's Interior, International Relief Union, International Union of Geology and Geophysics, the Red Cross, the Salvation Army, and the Sovereign Order of Malta.

C. Dr. Lee A. DuBridge, a member of President Nixon's Science Advisory Committee, served as the Chairman. The Co-Chairmen were Minister Plenipotentiary Carlo Calenda of the Italian Ministry of Foreign Affairs; Dr. Kazim Ergin, Professor of Geophysics at Istanbul Technical University, Turkey; and Darrell M. Trent, Deputy Director of the Office of Emergency Preparedness, the agency in charge of the United States Disaster Assistance Program.

D. At the Plenary Sessions on the opening and closing days, the delegates heard addresses by Dr. DuBridge; Dr. Gunnar Randers, Assistant Secretary General for Scientific Affairs, NATO; Minister Carlo Calenda; Dr. Kazim Ergin; Mr. Trent; Dr. Charles F. Richter, Professor Emeritus of Seismology, California Institute of Technology; Rogers C.B. Morton, Secretary of the Interior; Joseph P. Alioto, Mayor of San Francisco;

George A. Lincoln, Director of the Office of Emergency Preparedness; Dr. Clarence R. Allen, California Institute of Technology; Professor C. Martin Duke, University of California (Los Angeles); and Dr. Jack Oliver, Lamont-Doherty Geological Observatory of Columbia University.

E. John A. Volpe, Secretary of Transportation, and Mrs. Shirley Temple Black, Deputy Chairman, United States Delegation to the Preparatory Committee, United Nations Conference on Human Environment, spoke at a luncheon on the first day.

II. Conduct of Meeting

A. Following the opening plenary session, the meeting was devoted to work group sessions on the following subjects:

1. Earthquake Disaster Prevention and Hazard Reduction Techniques;
2. Emergency Relief Organization and Operations;
3. Rehabilitation and Recovery;
4. Rôle of Governments, Universities, Industry and Volunteer Organizations.

B. Each subject was discussed in detail and each work group Chairman prepared a report reflecting the results of his group's discussions and presenting a series of action recommendations. These recommendations were discussed during the plenary session on the final day of the meeting. Working Group reports are attached as Annex A.

III. Observations

A. This was the first international meeting of eminent authorities from all disciplines relevant to the problem of earthquakes. The meeting provided a forum for open and comprehensive exchange of information and experience among those responsible for governmental programmes for mitigating the social and economic effects of major earthquakes, as well as the scientific aspects of such phenomena.

B. Emphasis was given to formulating practical recommendations which could be implemented in the near term by interested nations, either individually or collectively. Attention was also given to current applied research and promising areas for future study.

C. It was generally agreed that the primary responsibility for protecting the life, health and property of the people within a country lies with the government of that country. In this regard, most of the recommendations which emanated from the meeting can be best applied on a national basis. Some rommendations, however, are international in scope and are more properly the concern of international organizations. These recommendations have been grouped together under the headings of "International Level" and are being submitted here, along with the recommendations for appropriate action by interested nations at the "National Level", for ultimate consideration by the Council.

IV. Meeting Recommendations

A. Based on the conclusions and recommendations of the several working groups of experts(1), plus subsequent review by responsible officials of the pilot and co-pilot nations, the following actions are recommended:

1. At the International Level

(a) That countries seek good co-operation with all international organizations rendering disaster assistance and that in so doing they should, in principle, support the proposals calling for an expanded United Nations rôle in the area of disaster assistance, and in particular the resolution of the Economic and Social Council. No. 1612 of 29th July, 1971, with the reservation that certain individual questions will be examined in greater detail; and further that NATO should endeavour to harmonize and co-ordinate its own programme for co-operation in the area of disaster assistance with similar programmes of other international organizations, particularly with the United Nations programme now under development(2).

(b) That countries press for increased support of UNESCO programmes dealing with earthquakes or related phenomena, especially the UNESCO assisted regional seismological centres, as part of the effort to enhance international earthquake research and information exchanges. These centres deserve further international support as a means of:

(1) encouraging interdisciplinary research on earthquake prediction, disaster response, and rehabilitation and recovery;

---

(1) See Annex A
(2) See Annex B

(2) promoting exchange of technical personnel, results of research (including developments in improved monitoring techniques), and other pertinent information among nations;

(3) providing technical consultative services to any government requesting help on earthquake related problems;

(4) developing models, guidelines and standards for use in different types of earthquake-prone areas.

(c) That interested countries support and participate in an International Technical Training Programme designed to train teams from earthquake-prone countries in the use of modern techniques and equipment in search, rescue and recovery operations. These teams could be used by governments to conduct similar courses in their respective countries for additional national teams upon completion of their training. A pilot country proposal for establishing such a programme is under active consideration by the co-pilot governments.

(d) That countries support international efforts to facilitate foreign assistance in time of disaster by removing or modifying existing barriers to the swift movement of goods, services, and disaster relief personnel across international boundaries. Toward this end, member governments are urged to accept and implement the recommendations set forth on this subject by the Customs Co-operation Council in June of 1970, Annex C.

(e) That countries support efforts in the United Nations to examine the feasibility of establishing a global natural disaster warning system (pursuant to the Secretary General's feasibility study on the subject in response to UNGA Resolution 2717 of December 1970).

2. At the National Level

(a) Earthquake Prediction and Warning

Recognizing that many difficulties exist with respect to accurate earthquake prediction, all interested countries are urged to:

(1) employ available and emerging technology in studying known fault areas and, where appropriate, to exchange resultant findings with other countries;

(2) collect and update geologic and seismic data on a continuing basis and to make this data available to local and national planners and to other interested countries. There is a need for more and improved geological and "seismic risk" mapping;

(3) improve instrumentation(1) for monitoring the effects of earthquakes and collecting relevant data which can be utilised in developing better engineering concepts.

(b) Land Use, Structural Design and Building Codes

Interested countries are encouraged to:

(1) accelerate research into analysis of earthquake resistant materials for structural use. To avoid duplication and excessive costs, any necessary materials testing should be conducted on a co-operative basis and results disseminated accordingly. In this regard, consideration should be given by the pilot and co-pilot countries to holding an international meeting relating to this subject within one year of the adoption of these proposals;

(2) incorporate the results of research and testing and of experience gained in actual earthquake situations in national and/or local building codes with minimum delay;

(3) discourage, where feasible, high concentrations of people or public facilities in high-risk areas; e.g., through legislation, education or any other appropriate means;

(4) strengthen procedures with respect to inspection and supervision of new construction in high-risk areas, especially dams, large office buildings and apartments;

(5) where practicable, phase out of use or strengthen non-earthquake-resistant buildings, particularly in high-risk areas.

---

(1) This refers to a recommendation from Working Group I calling for the construction of an "organised network of strong motion measuring instruments" in all areas of the world subject to major earthquakes in order to obtain data for more meaningful research.

(c) Emergency Operations and Recovery

Interested countries are encouraged to:

(1) develop and test improved search and rescue techniques (the proposed International Technical Training Programme could serve as a clearinghouse for research and information exchange on advancing the state of the art in this area);

(2) plan for the use of alternate means of communication and transportation in earthquake disaster situations;

(3) where possible, expedite research and development of innovative transportation modes, such as vertical short take-off and landing aircraft (VSTOL), to supplement the use of helicopters and thus provide for greater and more rapid airlift capability to and from disaster areas;

(4) institute forthwith detailed contingency plans for:

(a) the movement of people from stricken areas;

(b) the inventory and pre-allocation of available resources (both human and material) for the performance of essential disaster functions;

(c) the post-disaster development of earthquake-prone areas that can provide a suitable basis for reconstruction;

(d) the acquisition and stock-piling of emergency packaged hospitals, medical supplies, etc.;

(e) the prompt field investigation of earthquake damage.

(5) undertake programmes of mass education in earthquake-prone areas. The use of primary and secondary school courses, mass media techniques such as television and films for use in schools, community centres and public broadcast, and wide dissemination of illustrated material should be explored, where appropriate, on a co-operative basis;

(6) develop a programme to recruit, train, and deploy volunteers, in the event of a disaster, in accordance with the specific needs of the country. They should be trained in the organization of facilities, movement of people to shelters or safe areas, and general policing of community movement in the wake of an earthquake. Training of citizen wardens could be performed by travelling teams of experts;

(7) in co-operation with universities, engage in continuous research on socio-economic and legal consequences of disasters;

(8) employ a single agency to co-ordinate nationally and/or locally all necessary emergency operations, and to act as the point of contact with multi-national centres. Such an agency should have available a contingency fund for financing sudden and massive relief measures when needed and should be responsible for ensuring:

  (a) clear and unambiguous delegation of responsibility for all operations;

  (b) co-ordination of operations handled by separate organizations;

  (c) adequate support and administrative services for all elements providing assistance;

  (d) timely and adequate information for decision making and public dissemination;

  (e) utilisation of private sector resources.

V. Recommendations to the CCMS

The pilot countries request the CCMS to:

A. Approve the report of the pilot countries, noting the recommendations of the working groups at Annex A;

B. Forward the report, as approved to the Council for its approval of the recommendations pertaining to actions at the "international level";

C. Recommend that the Council invite interested countries, as appropriate, to implement recommendations pertaining to actions at the "national level".

REPORT OF THE WORKING GROUP ON EARTHQUAKE DISASTER PREVENTION AND HAZARD REDUCTION (WORKING GROUP I)

Thirteen presentations addressing the five areas of general discussion were given by representatives from various nations during the one and one-half day session. Issues were opened to general discussion and questions following each address. A brief summary of most of the issues in each of the sub-areas is presented herein followed by recommendations. The sub-areas are:

(a) hazard evaluation;

(b) building codes and other hazard reduction techniques;

(c) economic and legislative aspects of hazard reduction techniques;

(d) land use planning; and

(e) disaster and education information programmes.

(a) Hazard Evolution

Different aspects of earthquake hazards such as seismicity, faulting and ground motion were presented and discussed. It was generally agreed that reliable data still was a vital need and that programmes for improved strong motion instrumentation should be pursued both from national and international viewpoints. Seismic information must be coupled with appropriate geologic hazard information so that national risk judgments can be arrived at in aiding decision making.

(b) Building Codes and other Hazard Reduction Techniques

Types of building codes reflecting different regions were discussed. The issue of legislative action in code formulation and the importance of effective inspection and supervision of ensuing construction was identified as a universal problem. The intent of codes can be evaded or undermined by laxness in inspection and supervision. The necessity for codes to reflect a total picture, in the sense of including not only structural elements but other contents of buildings which are potential hazards, was reviewed. The need for eliminating some of the most serious hazards in existing buildings by minimal cost efforts, such as the removal of parapets and/or the improvement of structural ties, was identified as a means for reducing the loss of life.

(c) Economic and Legislative Aspects of Hazard Reduction Techniques

The trade-offs between increasing earthquake resistant design construction and "acceptable" risks were discussed with a view towards the economic issues involved. The concept of an acceptable risk, particularly where the notion of risk involved both economic loss as well as the potential loss of life, was reviewed as both a moral and economic problem. New construction, it was agreed, generally was an easier problem to solve when compared to already existing structures in densely populated regions. Legislative issues were particularly dependent on the individual political structures of the represented nations.

(d) Land use Planning

The problems in land use planning represent a more difficult problem in urban concentrations when compared to rural areas. In urban areas, great pressure is often brought to bear upon planning agencies because of the economics of the land in question. Too often, uncontrolled construction is instituted on sites which, because of their geologic hazards, are unduly high risks.

(e) Disaster and Education Information Programmes

Public information and education programmes become a particularly difficult problem when they are directed towards events which have only a statistical likelihood of occurrence. Disasters such as earthquakes or other natural disasters which tend to occur at widely dispersed and uneven intervals of time pose problems from a sociological point of view in the sense that effects of overemphasizing the problems can cause as adverse a reaction as can underemphasizing the problem. It was generally agreed that research in the response of large masses of people to educational and information programmes should be instituted.

RECOMMENDATIONS:

EARTHQUAKE DISASTER PREVENTION AND HAZARD REDUCTION

The recommendations listed herein, in the judgment of this Working Group, represent what is felt to be a reasonable approach towards the mitigation of some of the most significant potential effects of disasterous earthquakes. It is recognized that not all the countries represented at this international meeting are subject to earthquakes in the same degree. Additionally, it is not possible for one single set of general recommendations to adequately reflect every point of view as to appropriate national priorities. However, the implementation of all of the following applicable recommendations within the context of national needs and resources will lead to very major reductions in earthquake hazards.

Recommendation 1: Data Collection and Distribution

All existing relevant data, both historical and current, in the fields of engineering, geology, seismology, geodesy, and oceanography should be systematically collected both nationally and internationally, and these data should be made available to appropriate international sources through effective channels of communication.

Recommendation 2: Increased and Improved Geologic and Seismic Risk Mapping

The need for more and improved geologic and seismic risk mapping is great as one basis for earthquake hazard reduction. These maps must be practical in order to be an effective aid to national and regional planning. Public policies should be directed at discouraging the development, where practicable, of land which is known to be in a high risk area. These areas, if it is necessary to use them at all, should be used for purposes which, in the event of an earthquake, would minimise the loss of life and property through low population density or open space uses. Where consistent with national policies, governmental pressures, in the form of legislation as well as social pressure and economic aid, should be brought to bear to prevent the inappropriate use of high risk areas.

Recommendation 3: Need for Increased Strong Motion Equipment

An organised network of strong motion measuring instruments must be installed and maintained in all those areas of the world subjected to major earthquakes to obtain information on the effects of:

(a) Various geologic formations and foundation materials on strong ground motion;

(b) Distances from potential causative faults in various geologic settings on strong ground motion; and

(c) Strong ground motion within structures and also on ground adjacent to these structures.

The opportunity to record a major earthquake in the epicentral region is rare and no reasonable opportunity for recording such data must be lost. Without this fundamental data, all subsequent research is based on assumption.

Recommendation 4: Replacement of Dangerous Buildings

Dangerous buildings which are not earthquake resistant should be phased out of use and replaced as soon as the economy of the country permits. It is probable that in most areas of the world, the maximum loss of life will be due to the collapse of hazardous buildings. Some types of minimal cost for binding or interconnection of structural elements will reduce many of the greatest of building hazards.

Recommendation 5: Field Investigation of Earthquakes

Earthquake damage to structures must be examined promptly after each destructive earthquake. This requires that arrangements for providing information must be developed before the disaster in order to ensure rapid and easy access to the sites. Construction drawings and other pertinent data must be made available. Some of the objectives of field investigation of earthquakes are:

(a) To examine the performance of local building codes, materials, construction practices and design methods;

(b) To train engineers in the unique problems of earthquake resistant design by observation of the effects of earthquakes and to develop their judgment in this specialised field. These trained engineers should then be the professionals upon whom the respective nations must rely to design their important structures and engineering works, and to influence construction practices;

(c) To examine the geology of the area, including the geology of faulting and landslides among others;

(d) To study possible solutions to land use problems.

Recommendation 6: Improved Safety of Dams

The possibility of the failure of a dam during an earthquake constitutes a serious threat to the safety of many communities. It is highly desirable that the greatest care be exercised in the design and construction of dams and that there be review of existing dams. Review agencies or regulatory standards should be established to ensure that these structures are constructed in accordance with the best available earthquake resistant design practice.

Recommendation 7: Earthquake Resistant Housing

Practical construction approaches should be applied to develop earthquake resistant housing, using materials and construction practices suitable for the local conditions. This information should be made available on an international basis.

Recommendation 8: Building Code Improvements and Enforcement

Building codes must be written to reflect the special requirements of earthquake-prone areas, including the necessity for ductility as well as strength. Attention must be given not only to the traditional "structural" elements but also to those architectural and equipment features which could create life hazards. Building codes cannot achieve these objectives without adequate inspection and supervision during construction.

Recommendation 9: Public Awareness of Earthquake Hazard

The general public should be made more aware of the problems of living and building in earthquake-prone areas. National and/or local programmes should be undertaken to educate the population as to what can be expected in various earthquake-prone areas, and this should be accomplished without resort to panic procedures. The national governments should make the population aware of programmes undertaken on their behalf to minimise the loss of life and property. Lastely, national governments must have realistic rescue and rehabilitation plans which are ready to be activated in the event of an earthquake.

REPORT OF WORKING GROUP II ON EMERGENCY ORGANIZATION AND OPERATIONS

I. Introduction

1. This Working Group examined the subject of emergency relief organization and operations. It held informative discussions on this subject on three days. Approximately 30 individuals, representing nine countries and international organizations, participated in the Group's work.

2. Prefetto Guiseppe Migliore of Italy, Chairman of the Working Group, welcomed the participants. In his opening statement the Chairman recalled the work that had been done in Venice on the problem of flood mitigation under the NATO Committee on the Challenges of Modern Society's disaster assistance project. He called attention to the fact that many common problems exist in providing emergency relief assistance, no matter what the cause of the disaster. However, severe earthquakes, because of the massive damage that may result, the lack of any advance warning of their occurrence, the para-earthquake effects, such as tsunamis, fires and aftershocks, present problems unlike any other disaster. The Chairman then commented briefly upon the specific topics of emergency relief organization and operations upon which the Group would focus. They were:

(a) determination of emergency relief needs and requirements;

(b) structure of emergency response organizations;

(c) disaster services for victims;

(d) national/local government co-ordination;

(e) search and rescue;

(f) population evacuation;

(g) co-ordination of international assistance;

(h) restoration of essential services.

II. Proceedings

3. Dr. Aurigemma began the actual work of the Group by making a short presentation that described the organization in Italy that provides assistance in the event of a disaster. The speaker referred to specific accomplishments by the organization in recent earthquake and other natural disasters.

4. Mr. Brazee distributed two earthquake scenarios and commented briefly upon them. These papers provided reference material to the participants regarding the potential problems that nations may face in responding to serious earthquake disasters.

5. Mr. Jones then stated that if a severe earthquake struck a major metropolitan area, a serious blow to the economy of any country would result. If such a disaster were to occur, the affected area would need swift assistance from the national government and from other governments. The speaker then suggested priority needs that should be met as well as several of the immediate response requirements of the area.

6. Dr. Schaefer then made a brief presentation regarding methods and materials provided by the Federal Republic of Germany to countries stricken by serious disasters.

7. The Working Group then discussed specific methods to respond to an earthquake of this magnitude. It was agreed that this question needed to be examined in two perspectives. The first being on a national level, the second on an international level.

8. It was the conclusion of the Working Group that considerable progress can be made at both levels. However, it will require a considerably larger effort by national governments.

9. At the national level the existence of a national plan to respond to serious disasters is then indispensible. To complement this plan, a strong, well-trained disaster assistance organization is needed. At the international level considerably more co-operation needs to be accomplished. A positive step in this direction would be for countries to co-operate more in planning for earthquake catastrophes. Therefore, if a country is stricken by a serious earthquake, other countries would be able to respond quickly and prevent further damage and loss of life. It was noted that considerable work must be done to make this a reality. The rôle that NATO could take in this area was discussed in detail.

10. Mr. Kofsky discussed the capabilities of the United Nations and Mr. Bay-Rossi the work of the International Relief Union.

11. The Chairman stressed throughout the work of the Group that one of its primary objectives was to develop recommendations that would result in increased integration of national efforts and participation in disaster relief activities. The results of this would substantially increase the solidarity and well being of the people of the world.

12. The Working Group then examined the sub-topics in considerable detail. Presentations were made by many individuals. These provided considerable assistance in the formulation of the Group's recommendations.

III. Findings and Recommendations

13. The Working Group noted that its task was similar to the one assigned the Emergency Operations Panel at the flood mitigation meeting in Venice, and its work furthers the effort of the Panel in Venice. Both meetings were held under the aegis of the NATO Committee on the Challenges of Modern Society. The conclusions of this Working Group substantiated the findings in Venice. The primary conclusion was that countries should have national plans and international assistance procedures in order to respond to serious disasters. More information on disaster assistance may be found in documents AC/274-D/10 and AC/274-D/13(1). These are, respectively, the final recommendations of the Venice meeting and the NATO co-operation for emergency disaster assistance in peacetime.

14. Because of essential similarities, the findings at Venice were applicable to the emergency organization and operations in response to earthquake disasters. These recommendations are listed below:

1. Each interested government should designate a single centralised organization with continuing responsibility for disaster assistance activities. Such organizations should be structured to allow maximum use of technical skills of existing, operating elements elsewhere in the government.
2. Each interested government should designate one agency as the recipient of earthquake assistance requests. In this way, stricken countries could more rapidly make known the nature and location of their needs and the best methods of shipments with regard to border formalities and tax regulations.
3. It is recommended that interested governments initiate procedures for sending technical or specialised personnel to assist or observe emergency operations in other countries. Such personnel would travel to a country struck by an earthquake at the request of the host government. Governments interested in receiving technicians and observers at times of disaster should make appropriate stand-by arrangements.

---

(1) Final version to be issued as C-M(58)102, 1971 edition.

15. The essential points of the NATO document on international co-operation are summarised below:

1. Interested nations should exchange all useful data relating to the mitigation of the hazards of earthquakes and information relating to potential assistance.

2. In the event of a serious disaster, the stricken country and the nations wishing to provide assistance should contact each other directly and make all necessary arrangements for the provision of assistance.

3. At the same time, the stricken country may inform the Secretary General of its assistance requirements. The Secretary General can then take all necessary and urgent steps to facilitate or help expedite the delivery of aid items requested by the stricken country and to locate as far as possible, the items that have been requested and which have not been obtained.

16. On the basis of the Venice findings and the principles enumerated in the NATO document concerning co-operative assistance in natural disaster, it was the intent of this Group to develop in a broader way and to give more concrete efficiency to the CCMS initiative of international solidarity. The Working Group has developed the following recommendations, that in its opinion, are of priority importance:

1. That countries without national plans to respond to a major disaster such as a massive earthquake, should develop these plans as soon as possible. In developing the plan, they should consider, first, the use of their own resources and capabilities to the greatest extent possible and in the most efficient way. The plan also should provide a mechanism for international co-operation, when supplemental assistance from other countries is required.

2. That interested countries should promote bilateral and multilateral agreements to facilitate assistance in case of emergency. For example, in the area of transport, both for personnel and materials; crossing of borders; and in any other possible way to expedite required aid.

3. That interested countries should attempt to reach agreement on possible conformity of assistance materials and equipment that considers the specific conditions for which they are destined and will be compatible or adaptable to ensure integration with similar equipment in the stricken country. For

example, the materials should be easily transportable; durable; adequate for the climate; have minimum storage space and long shelf life. This recommendation applies especially to the following materials: tents, or any other type of emergency shelter, blankets, clothing, packages of emergency food, etc. It would be in the best interest of all countries to exchange information in advance of a disaster about the types of assistance each country may be able to provide.

17. The Working Group, recognizing the high social and human value of the initiative of CCMS, urges that the above recommendations be acted upon without delay by the interested countries in order to achieve a broader and more effective international co-operation as an element of a deeper understanding and solidarity among peoples.

REPORT OF THE CHAIRMAN

WORKING GROUP III ON REHABILITATION AND RECOVERY

Earthquakes are among the most destructive forces of nature. They occur with great frequency in many parts of the world, inflicting damage on a scale that often is beyond the economic capability of afflicted nations to repair without help from others. Emergency relief, however generously and wisely given, is not enough in a modern world. The rebirth of a shattered economy, the long-range reconstruction of homes and communities, and redevelopment of industry is essential if humanitarian and economic goals are to be achieved.

When disaster strikes a modern urban area, with its sophisticated money economy, the rapid and full restoration of that economy is the first major step in the long-range restoration of the area. There is no exception to the principle that a modern economic system requires the infusion of money in large enough amounts to restart the system and re-establish viable enterprises.

When disaster strikes in less developed rural areas rebuilding can usually be started through self-help measures and assistance from voluntary organizations, and, later, by actions designed to stimulate the economic growth and development of the area.

Out of the experience of the past decade has come a set of principles and practices that can guide nations through the difficult process of rebuilding, or in aiding others to rebuild a shattered economy. Because each disaster has a unique pattern of damage and disruption of the social system, some of the most desirable and effective approaches to recovery and rebirth in each instance will also need to be unique. However, all nations should be encouraged to recognise the prime importance of early and continuing action on matters of health, housing, employment and education. Unless citizens of a devastated area have adequate housing, medical care and productive employment the development and rebirth of the area will be significantly retarded. If the community is to have a viable future a strong emphasis on education will be necessary.

While technical assistance, economic and material aid from outside the disaster area are both necessary and desirable, the recipient local governmental units still have a significant rôle to perform. In the rebirth of a community system certain sociological considerations merit careful attention, especially citizen commitment and the involvement of local leaders. Where local participation in reaching decisions affecting the future welfare of the community contributes to rebirth, such involvement should be encouraged.

Within the guidelines of this philosophy, Working Group III addressed the question of rehabilitation and recovery following an earthquake. Mr. Stephen R. Tripp, the Chairman of the Working Group, opened the meeting with a brief summary of the material to be presented. He then discussed a list of issues which each participant had been given and which had been formulated to stimulate thinking and discussion. The Chairman's opening remarks were concluded with the introduction of Working Group participants.

The first part of the meeting was given over to a case study of the 1964 Alaskan earthquake which consisted of a film and four presentations. The film, "Response to Disaster," described the earthquake and showed some of the damage that resulted, and presented some of the reconstruction measures that were initiated within the first year following the earthquake. Mr. Joseph H. Fizgerald, who headed the Federal Field Committee for Development Planning in Alaska for five years following the earthquake, described some the of the problems entailed in co-ordinating assistance, formulating policy and implementing plans. Dr. Lidia L. Selkregg, who was deeply involed in reconstruction planning activities following the earthquake, then described some of the problems encountered in land use and planning for reconstruction. Dr. J. Eugene Haas, a sociologist, and Dr. George W. Rogers, an economist, who were both involved in many of the studies made following the earthquake, then described the social and economic process during reconstruction and the socio-economic impact of the earthquake. In all of these presentations, as well as those that followed, principles and suggestions for improving the rehabilitation and redevelopment process were considered.

The second part of the prepared presentations included two papers on the Peruvian earthquake given by Mr. Stephen R. Tripp, the Disaster Assistance Co-ordinator for the Agency for International Development, and Colonel Humberto Rosas Calderon of the Peruvian emergency and rehabilitation committee at Lima, Peru. Through the use of slides and graphs. Mr. Tripp and Colonel Rosas described the unique problems created by the mountainous geography and coastal plains of Peru, the relief effort and the rehabilitation and reconstruction programme underway.

The Italian members of the Working Group, under the guidance of vice-chairman Dr. Guido Ortolani, presented four papers which showed different aspects of the Italian experience with earthquakes. Mr. Mario Delle Chiaie spoke of the problems of debris removal and the razing of unsafe buildings and presented an excellent document on the subject. Mr. Arrigo Fratelli described the re-establishment of essential services and the establishment of "temporary" towns built to house the affected population for periods of up to five years while permanent reconstruction took place. Dr. Giuseppe Colucci described the legal aspects of disaster assistance in Italy, and Dr. Raffaele Mezzacapo described the Italian programme and laws for rural disaster relief.

The remainder of the meeting was devoted to discussing many of the issues that had been formulated by the Chairman for stimulating discussion and to elaborating on the suggested approaches that came out of the various presentations. Not only the Panel members but also the 15 to 20 observers who attended the sessions added their observations in a useful and constructive manner. From these discussions, the following "sense of the meeting" resulted, along with a series of recommendations for enhancing the reconstruction and redevelopment processes that must be implemented following an earthquake.

INTERNATIONAL ASSISTANCE

The Panel recommends: that nations should be encouraged to offer disaster reconstruction/redevelopment assistance to one another and, when accepted, that grants in aid, specified materials and supplies, technical advice, and concessional loans be mutually arranged, or co-ordinated through international institutions such as the United Nations or regional organizations, and the International Red Cross.

NATO PILOT PROJECT ON TECHNICAL ASSISTANCE

It is recommended: that NATO develop a capability for rapid assessment of disaster damages in order to assist the member states in reconstruction/redevelopment planning, technical analyses, and preparation of cost data and contracts. It is also recommended that this take the form of a pilot project in order to determine whether it would be feasible and practicable to have available such a capability on a world-wide basis. Further the results of the NATO experience could be made available to the UN, OAS, other nations and the International Red Cross, etc. The offer should be made with the understanding that it is purely technical, that the country concerned would determine the nature of its own programme.

RECONSTRUCTION GOALS AND PRIORITIES

It was agreed that what generally is called the expense of a disaster is, in reality, not an expense but an investment. Concentration on economic growth of a disaster-struck area ensures that reconstruction efforts provide a better, faster-growing economy and thus fully offsets the cost of the effort. However, this priority cannot be established at the expense of political, social and psychological factors.

It is recommended: that nations adopt, as a primary goal of reconstruction, the "rebirth" of the affected area and not merely the re-establishment of what existed before and, further, that economic regeneration be established as a first-order priority after the immediate well-being of the victims has been assured.

RECONSTRUCTION MODELS, GUIDELINES AND STANDARDS

In modern society reconstruction goals and plans must begin long before the earthquake. Earthquake hazard abatement, management of the disaster-struck economy, and land use planning requires an overall inter-disciplinary endeavour involving both public and private responsibilities.

It is recommended: that countries seek international support, including that of the United Nations and regional organizations such as NATO, OAS, OAU, and specialised groups such as UNESCO, UNDP, International Association of Earthquake Engineering, International Council of Building Research and Documentation, International Union of Architects, Earthquake Engineering Research Institute, Pacific Fire Rating Bureau, etc., to develop models, guidelines and standards for use in different types of earthquake-prone areas in order to improve the reconstruction and redevelopment process.

LEGAL CONSIDERATIONS AND RECOMMENDATIONS

The Panel recognised that laws applicable to disaster rehabilitation and reconstruction determine to a large extent the effectiveness of the course of redevelopment. The Panel also noted that national legal systems are sufficiently disparate to preclude generalisations concerning recovery measures and property rights. It was generally accepted by the Panel that the laws of each nation concerning disasters should be (a) adopted in advance as part of the body of organic law in order that delays in recovery can be aovided, and (b) written in such a way that they protect the rights of the affected population and encourage the re-establishment of the acceptable life style of the people.

The Panel recommends: an international meeting be convened to formulate and propose an accord through which signator nations, in time of disaster, can remove or modify barriers to foreign assistance that may exist due to laws within the nation that are designed to cover its international relations under usual non-disaster conditions.

RESETTLEMENT

Because of far-reaching socio-economic problems in resettlement of populations struck or threatened by disasters, countries may desire to seek assistance from international institutions. It is recommended: that the resettlement of disaster victims be proposed as an Agenda Item for the United Nations Conference on Human Environment in 1972.

SELF-HELP PROJECTS

In many less developed nations or regions a significant part of the disaster reconstruction effort is dependent upon self-help. The victims provide the labour while the government or international organizations provide tools, materials and guidance.

Recognising the importance of self-help and the need to facilitate its use, it is recommended: that nations pool their technological expertise by establishing an international programme to develop self-contained self-help projects, e.g., pre-packaged home-building kits which include the necessary tools and pre-cut materials. Appropriate instructional material to accompany these projects should also be included.

INSURANCE

The Panel discussed the problem of insurance as a method of financing redevelopment and concluded that there is not at this time any proposed insurance system which could be adopted on a world-wide basis and that governmental assistance supplemented by international aid remains the most effective method of assisting stricken areas.

UNIFIED DATA COLLECTION METHODS

In order to develop sound principles for reconstruction, the Panel concluded that it was essential to collect systematic data on the rehabilitation and recovery process as conducted in different countries. Further, because of the long time-frames associated with the reconstruction process - these may range from an average of five years to as much as twenty years in some countries - such data should be collected over the entire period. Finally, it concluded that guiding principles could be better identified and formulated if the large quantities of data collected following a disaster could be systematically pooled and utilised. This now is handicapped by confounding that arises from using various non-compatible study methodologies.

Recommendation: to alleviate these problems and to bring to bear the most sophisticated research and data-gathering capabilities, it is recommended: that an international body of experts from various scientific disciplines be convened to formulate a set of unified data-collection methods which then could be used by all nations to provide answers to immediate questions while forming a data base which, over time, would contribute to our knowledge of how best to cope with the long-range consequences of disasters.

REPORT OF WORKING GROUP IV ON THE ROLE OF GOVERNMENTS, UNIVERSITIES, INDUSTRY AND VOLUNTEER ORGANIZATIONS

I. FOCUS AND ASSUMPTIONS

The specific rôles of governments, universities, industry and volunteer organizations in major disasters such as earthquakes will vary depending on the particular social, economic and political structures of the societies involved. However, in all cases these groups can play important parts in national or large-scale catastrophes. In most cases, in fact, these groups do have major rôles in the preventive, response and recovery aspects of disasters.

Governments, almost by definition, have a prime responsibility for the safety and welfare of their citizens. This responsibility may be assigned in different ways to different levels of government - the central, national or Federal level; the State, province or regional level; and the community, city or local level. But in all cases the governmental organization is a very major, if not the key, unit in the disaster-related activities of a society.

Universities, almost everywhere, are major repositories of bodies of knowledge and skills applicable to any kind of problems human beings and groups might face. In some societies, higher education shares its training and research functions with other institutions. But in all societies, universities are sources of theoretical and practical knowledge and skilled personnel that can be used for the prevention of, the response to, and the recovery from major disasters.

The industrial bases of different societies differ widely in their degrees of complexity and specialisation, in the nature of goods and services produced, in their administrative management, and very many other socio-economic and socio-political aspects. However, there are some components of the industrial complex that are relatively similar in fundamental structure and functions and, equally as important, are crucial groups in disaster-related activities. The mass media systems are good examples of this. Mass communication organizations can, in fact must, play a prominent part if there are to be effective and efficient steps taken to prevent, to respond to and to recover from societal catastrophes such as are threatened by massive earthquakes.

Among the four groups we are discussing, the greatest difference from one society to another is probably among the volunteer organizations. Their very existence and number, and their functions and relevance vary considerably according to the socio-economic and socio-political structures of different social systems. However, volunteer organizations are important either directly or as crucial supplementary emergency sources in the disaster-related activities of a number of societies. Furthermore, volunteer organizations in many nations play a particularly noticeable rôle in certain aspects of international disaster relief after national catastrophes. Various religious as well as non-sectarian, charitable and welfare groups are notable for efforts along this line. As such, it is necessary to take into account the part volunteer organizations can plan in disaster situations.

What various groups can or cannot do in mass catastrophes will in part vary according to the time period or phase involved. In a gross although in a logical way, activities with regard to disasters can be divided into three phases: (1) the pre-impact or preventive phase, (2) the impact or response phase, and (3) the post-impact or recovery phase. Other differentiations (e.g. using space as well as time) could be made, but the threefold distinction is useful and adequate for many purposes, and is more applicable to an earthquake than to some other disaster agents.

In general, societies have tended to organise means of recovering from catastrophes before they have created measures for responding directly to disaster impacts. Thus, laws and groups to deal with post-impact problems have generally been established before the development of measures and organizations to cope with the consequences of dangerous and threatening agents. Last of all has come efforts to create means and social arrangements to prevent or drastically ameliorate catastrophes. For example, cloud seeding of hurricanes, zoning of flood plains, educating people to recognise tornado cues, earthquake building codes and other pre-impact activities such as the building and stocking of emergency operating centres, the training of personnel to monitor on a continuous basis signs of danger in the environment, and national disaster planning are all relatively recent innovations in the history of reactions to disasters.

The sequence involved can be seen in very highly disaster-prone countries such as Italy, Japan, Turkey and the United States. Roughly speaking, measures for post-disaster recovery have been followed by the establishment of procedures and organizations to deal with the direct impact of disaster agents. Only recently have come the systematic beginnings of moves in the preventive area.

For discussion purposes, it is useful to distinguish the various groups that can and that should be involved in disasters. For similar reasons, it is worthwhile to divide up the different disaster phases; i.e. prevention, response and recovery. But there is a danger in this approach, and it is that planning and research about disasters will be artificially segmented. Governments, universities, industry and volunteer organizations not only co-exist with each other, but of necessity these groups must intereact with one another at times of catastrophes. Similarly, recovery measures are not independent of what pre-impact preventive and protective actions were taken; both are related to response actions at time of disaster impact.

There must be overall planning. There would not seem to be any need to document this assumption. However, the inter-relationships of various groups in a society that might be involved in disaster-related activities need to be made explicit. In these days of interdependency and closer social links, it is also necessary in emergency planning to take into account the possible assistance nations might render to one another in connection with potential or actual massive disasters. Thus, there is the necessity of national plans and the desirability of international planning.

While disaster planning must be overall planning, it needs also to be realistic. That is, if efficiency and effectiveness are to be achieved in prevention, response and recovery, specific plans must take into account the particular social, economic and political characteristics of the societies involved. In particular, disaster plans should avoid being modeled after those that might be most appropriate only for nations with a certain kind of technological base or governmental structure. To be realistic, plans must be in accord with the dominant social characteristics of the society in which the plan is to be used. This does not mean that there are not certain common elements in any kind of planning for catastrophes; it merely suggests that some dissimilarities between plans are as necessary as the probability of all disaster plans having certain things in common.

Realistic plans require knowledge of disasters and societal reactions to them. Such knowledge can be obtained through direct experience or from the knowledge of others. In either case, the knowledge cannot be organised and maximally used unless systematic study and research are carried on. This can take a variety of forms from international research centres or co-operative and joint inter-nation research efforts to conferences of experts or development of specialised laboratories. The existence of basic and applied research and study would not only contribute to the creation of knowledge about disaster phenomena but would also help in the dissemination of information that could be used in preventive, response and recovery aspects of catastrophes. Systematic study would also help in developing the kind of disaster planning that is not currently necessary but would be required if certain kinds of scientific advances were made; e.g. the development of predictive measures for earthquakes parallel to those currently available for certain other disaster agents such as hurricanes or floods. All of this requires adequate funding and administrative support at both national and international levels. With systematic knowledge there can be hope for improving the capabilities of governments, universities, industry and volunteer organizations to prevent, respond to and recover from massive disasters such as large-scale earthquakes.

II. GENERAL OBSERVATIONS

The discussions of the Working Group roughly focused around three topics: (1) disaster organizations and goals, (2) disaster planning and training, and (3) disaster studies and research. Among the major conclusions or observations made were the following:

A. Disaster Organizations and Goals

To have different co-ordinating centres at the national level for different kinds of disasters is inefficient and confuses lines of authority. There appears to be no good reason to have separate operational or co-ordinating centres solely for earthquakes. There is a tendency for existing centres to be manned by personnel with backgrounds, skills and experiences in only a limited number of relevant areas, and for such centres to lack sufficient funds for quick and immediate use.

Considerably more attention has been paid to how to respond to disasters than to ways to prevent or to protect against them. There also seems to be some variation in the standardisation of technical protective measures such as land zoning and building codes.

Information about disasters at the time of their occurrence is seldom complete or fully accurate. There is a strong tendency to ignore information or news about disasters until they occur, except for occasional dramatic and often scientifically incorrect predictions. Myths and misinformation about disasters abound in popular thinking and to a degree also among some officials.

Many groups are involved in international disaster relief, although the number is unclear. These different groups appear in general to have little knowledge about the activities of one another, and some are uncertain of what governments and other groups expect of them in disasters.

There is not enough exchange of information already available about the sheer facts of disasters, the means being used in different places to combat them, and the scientific and technical studies currently under way. Interested scholars, officials, emergency planners and administrators have considerable difficulty in learning where relevant information is available.

B. Disaster Planning and Training

There do appear to be some factors relatively unique to earthquakes, such as the dangers inherent in aftershocks, that require special attention. Other features, such as the total current lack of warning and the possibility of tremendous destruction of both lives and property, while not unique to earthquakes, would seem to demand more attention in planning and research.

Disaster plans often have a number of weaknesses. Lines of authority are not always clear nor are the specific relationships of emergency groups to one another. There is frequently a lack of up-to-date information on the minimum absolute quantities of food, shelter, health services and the like needed in given localities, or on what important network systems, such as those of power or water, are particularly vulnerable to a disaster.

There are problems, and disaster plans are not always clear on this, as to how immediate and accurate knowledge of damage after a disaster is to be obtained. The necessary information is difficult to obtain and frequently is gathered by many groups. Often, too, the information is never collated in any one place.

For many reasons, assistance to victims of a disaster is sometimes unintentionally inequitable or discriminatory.

Attempts to develop disaster organizations, disaster plans and disaster personnel as totally separated or segregated entities from everyday life are unrealistic. Everyday emergencies present opportunities for continual training and a partial testing of plans on a small scale.

While organizations must bear the burden of the response in a disaster, it is necessary to train citizens to recognise certain aspects of disasters, possible individual responses to them and appropriate actions, especially at times of impact. Such information ought to be a part of the everyday knowledge of the individual citizen. As a practical measure, it is probably easier to convey such information to children as a regular part of their schooling, perhaps as part of their health education.

The possible rôle of informal volunteers and organised volunteer groups in disasters is very complicated. Some attention has to be given to what should be done with the typical massive convergence of informal volunteers on disaster sites. The position of volunteer organizations is somewhat clearer, but often activities are carried out on the basis of informal understandings which sometimes become the basis of informal understandings and problems. The functions of volunteer organizations, their relationships to one another, and the limits of their responsiblities all need to be clarified and somewhat more formalised at both the national and international level.

A major problem in disasters is the convergence of mass media personnel on disaster officials. There is often considerable duplication of effort. In addition, unverified information at times is circulated because of the difficulty mass media personnel have in obtaining accurate information.

C. Disaster Research and Study

Perhaps the most serious weakness in disaster research has been the consistent failure to take advantage of the immediate study that would be possible during or immediately after a large-scale disaster. This has been particularly true with regard to obtaining knowledge about the human and social aspects of the disaster. The lack of support for such immediate studies during the emergency period is the basic reason, because skilled personnel has always been available for this purpose.

In addition, the disaster research that has been undertaken has tended to be of a very sporadic nature. There have been very few continuing research programmes on most aspects of disaster. Concentrated efforts allowing accumulation of knowledge and development of skilled researchers would seem a prime necessity if serious attention is to be given to disasters. Encouragement of advanced students in higher education to become interested in disaster research could help in the initiation of such programmes.

A special case might be made for paying some attention to the implications of a possible future breakthrough in earthquake prediction. Such an advance in knowledge would be relatively useless if practical advantage could not be taken of it.

The majority of disasters involve the evacuation of people either on a temporary or permanent basis. There appears to be little knowledge and understanding of the wide range of problems associated with such action. From a practical viewpoint, some attention should be given to this topic.

The crossing of national boundaries in the course of international disaster relief also poses a number of practical problems. The legal questions involved in such activity need to be answered.

While considerably more research is needed on practically all fronts, even the current body of knowledge available about disasters is not being used in the most efficient way. There is a serious gap between what is known and what is being applied. There could be considerable improvement in disaster prevention and protection and disaster response and recovery if the current scientific knowledge, physical and social, were effectively communicated to disaster planners, emergency officials and other personnel involved in coping with disasters.

The desire to obtain such knowledge and to share it is widespread. But there frequently exists relatively few means or mechanisms to continue to expand knowledge and exchange information.

On the basis of the above conclusions and observations, the Working Group agreed on the following specific recommendations. For purposes of presentation they are divided into three categories: recommendations about disaster organizations and goals, about disaster planning and training, and about disaster study and research. Adoption and implementation of these recommendations should improve the capabilities of human societies to prevent - if possible, to respond to - if needed, and to recover from - if necessary, large-scale disasters.

III. SPECIFIC RECOMMENDATIONS

A. Disaster Organization and Goals

1. Governments should establish a single central disaster agency to co-ordinate related activities of all relevant groups in all types of disaster.

2. The staff of a central disaster agency should be recruited from the social, physical and biological sciences as well as from professions such as engineering, medicine, public administration, law and social work.

3. Governments should ensure that the central disaster agency has a contingency fund available for sudden and massive relief measures.

4. Governments, as well as all other groups concerned with disasters, should give as much attention to pre-impact or protective measures against disasters as they do to impact response and post-impact recovery aspects.

5. National governments should take the lead in ensuring effective agreement among all levels of government, and with such groups as labour unions and professional associations in making seismic risk area evaluations, developing hazardous land zoning and building codes, and establishing other technical criteria for protection against earthquakes and other disasters.

6. Governments should make every effort during the impact or emergency period to ensure an accurate and timely flow of information to the public both within and outside the stricken area.

7. Governments, in co-operation with the news media and the universities, should provide pre-impact public education about disasters, as well as impact and post-impact public information.

8. Volunteer organization should clarify among themselves and in co-operation with other relevant groups their rôle in international disaster relief.

9. National governments should consider the feasibility of joining together in establishing a global disaster information centre.

B. Disaster Planning and Training

1. Governments, in conjunction with universities and volunteer organizations, should consider the special problems particularly associated with developing protection against, response to and recovery from earthquakes, and plan accordingly for such specific disasters.

2. Disaster plans should clearly indicate the range of authority and the specific functions of the various groups at different levels that might be involved in disaster-related activities.

3. Governments should make periodic inventories of vital support systems and other critical elements subject to change through time and that are likely to be disrupted in a large disaster.

4. There should be a pre-impact assignment of clear-cut operational responsibility to a specific group for the quick reconnaissance and damage assessment needed after massive and widespread disaster.

5. Disaster plans should ensure equity of assistance for victims, especially in rehabilitation activities.

6. Updating of disaster plans and training for disaster personnel should be partly accomplished through involvement of disaster organizations in everyday emergencies.

7. Governments should take the initiative in assisting schools at the primary and secondary levels to incorporate into their regular curriculum knowledge about disasters and related matters that could serve as training for appropriate individual responses in disasters.

8. Disaster plans should specify what rôle, if any, unorganised volunteers could play in times of disaster, as well as their disaster-related functions and relations to one another, in both their national and international disaster relief activities.

9. The mass communication media should agree among themselves on how to avoid duplication of efforts in obtaining verified information and in disseminating accurate news at times of great disaster.

C. Disaster Research and Study

1. Governments, in conjunction with universities, should develop stand-by provisions for funds and personnel to allow for immediate field studies by physical and social scientists on all aspects of massive disasters when they occur.

2. Governments, in co-operation with universities, should engage in continuous long-run or longitudinal research on the physical aftermaths, the biological effects and the socio-economic consequences of disasters.

3. Universities, perhaps with the help of governments, should offer fellowships and other inducements for graduate and professional students to specialise in disaster-related studies.

4. The research moving in the direction of attempting to predict earthquakes should be further encouraged and adequately funded, and supplemented by sociological studies on the implications for emergency planning of such innovations in prediction.

5. Governments, with the assistance of universtities, should examine the legal and jurisdictional problems as well as the social, psychological and socio-economic factors involved in the frequent necessity of short-run evacuation and long-run resettlement from disaster-stricken or vulnerable areas.

6. Studies should be made of the legal and jurisdictional problems involved in international disaster relief.

7. Governments, in conjunction with universities, should examine different ways of more quickly turning theoretical knowledge about disasters into practical applications.

8. Governments should encourage, through financial support of international conferences, visits of scholars and planners, joint or co-operate international research, and newsletters and reports, the quick and effective exchange of practical and theoretical knowledge about disasters.

RESOLUTION ADOPTED BY THE ECONOMIC AND SOCIAL COUNCIL OF THE UNITED NATIONS

1612(LI) Assistance in cases of natural disaster and other emergency situations

The Economic and Social Council

Bearing in mind that throughout history natural disasters and emergency situations have inflicted heavy loss of life and property, touching every people and every country,

Aware of the varying needs of nations experiencing such disorders, which present new challenges for international co-operation,

Concerned over the ability of the international community to come to the aid of countries in a disaster situation,

Recalling General Assembly resolutions 2435 (XXIII) of 19 December 1968 and 2717 (XXV) of 15 December 1970 on assistance in cases of natural disaster,

Expressing appreciation for the Secretary-General's comprehensive report (E/4994), and for its perceptive examination of all aspects of the question and taking note of the relevant passage in his statement to the Council at its 1773rd meeting on 5 July 1971,

Noting the study, annexed to the Secretary-General's report on the legal status of disaster relief units made available through the United Nations (ibid., Annex III),

Mindful of recent steps taken to improve evolving procedures in the United Nations system, voluntary agencies and individual Governments in the field of international disaster assistance,

Bearing in mind that assistance to meet the requests of the stricken countries without prejudice to their individual country programmes under the United Nations Development Programme can be an effective contribution to the rehabilitation and development of the stricken areas,

Bearing in mind also that the possible response of the International Bank for Reconstruction and Development and other credit organizations and development agencies to a request from the Governments concerned for complementary assistance for the stricken areas, without prejudice to the assistance provided by these organizations for the normal development programmes of the stricken countries, can be an important element in the reconstruction and development of the stricken areas, Noting the competence of the United Nations and its agencies, the United Nations Children's Fund, the United Nations High Commissioner for Refugees and the World Food Programme, to render assistance in disasters and other emergency situations,

Noting further the key rôle which the resident representative of the United Nations Development Programme should play at the country level,

Recognizing the vital rôles in international relief of the International Red Cross and other voluntary societies,

Recognizing further the necessity to ensure prompt, effective and efficient response to a Government's need for assistance at the time of a natural disaster or other emergency situation that brings to bear the resources of the United Nations, prospective donor countries, and voluntary agencies,

1. Calls on the Secretary-General to appoint a Disaster Relief Co-ordinator, who would report directly to him, and who would be authorised, on behalf of the Secretary-General to:

(a) Mobilise, direct and co-ordinate the relief activities of the various organizations of the United Nations sytem in response to a request for disaster assistance from a stricken State;

(b) Receive on behalf of the Secretary-General contributions offered to him for disaster relief assistance for particular emergency situations to be carried out by the United Nations, its agencies and programmes;

(c) Co-ordinate United Nations assistance with assistance given by intergovernmental and non-governmental organizations;

(d) Assist the Government of the stricken country to assess relief and other needs and to evaluate the priority of these needs, to disseminate this information to prospective donors and others concerned and to serve as a clearing house for assistance extended or planned by all sources of external aid;

(e) Promote the study, prevention, control and prediction of natural disasters, including the collection and dissemination of information concerning technological developments;

(f) Assist in providing advice to Governments on pre-disaster planning in association with relevant voluntary organizations, particularly with the League of Red Cross Societies, and draw upon United Nations resources available for such purposes;

(g) Acquire and disseminate information relevant to planning and co-ordinating relief for disasters, including the improvement and establishment of stockpiles in disaster-prone areas, and prepare suggestions to ensure the most effective use of available resources;

(h) Phase out relief operations under his aegis as the stricken country moves into the stage of rehabilitation and reconstruction but continue to interest himself within the framework of his responsibilities for relief, in the activities of the United Nations agencies concerned with rehabilitation and reconstruction;

(i) Prepare an annual report for the Secretary-General, to be submitted to the Economic and Social Council and the General Assembly;

2. Recommends that the Disaster Relief Co-ordinator be appointed by the Secretary-General normally for a term of five years;

3. Endorses the Secretary-General's proposals for a small permanent office in the United Nations which shall be the focal point in the United Nations system for disaster relief matters;

4. Recommends that this office be headed by the Disaster Relief Co-ordinator, be a distinct element within the United Nations Secretariat, and be augmented as necessary by short-term secondment of personnel for individual emergencies;

5. Requests the Secretary-General to prepare a study for its fifty-third session, taking into account any relevant suggestions and the experience gained by the Disaster Relief Co-ordinator, on ways and means to enable the Disaster Relief Co-ordinator adequately to perform the functions entrusted to him under the present resolution;

6. Further endorses the plan for a roster of volunteers to be drawn from experienced staff members of the United Nations system and interested non-governmental organizations, who could be made available at very short notice;

7. Recommends that the Disaster Relief Co-ordinator should maintain contact with the Governments of States Members of the United Nations and members of the specialised agencies and the International Atomic Energy Agency concerning available aid in emergency situations, such as food supplies, medicines, personnel, transportation and communications, as well as advice to countries in pre-disaster planning and preparedness;

8. Invites potential recipient Governments:

(a) To establish disaster contingency plans with appropriate assistance from the Disaster Relief Co-ordinator;

(b) To appoint a single National Disaster Relief Co-ordinator to facilitate the receipt of international aid in times of an emergency;

(c) To establish stockpiles of emergency supplies such as tents, blankets, medicine and non-perishable foodstuffs;

(d) To consider appropriate legislative or other measures to facilitate the receipt of aid, including overflight and landing rights and necessary privileges and immunities for relief units;

(e) To improve national disaster warning systems;

9. Invites potential donor Governments:

(a) To respond promptly to any call by the Secretary-General or by the Disaster Relief Co-ordinator on his behalf;

(b) To consider and to continue offering on a wider basis emergency assistance in disaster situations;

(c) To inform the Disaster Relief Co-ordinator in advance about the facilities and services they might be in a position to provide immediately, including where possible relief units, logistical support and means of effective communications;

10. Further invites all organizations of the United Nations system and all other organizations involved to co-operate with the Disaster Relief Co-ordinator.

11. Recommends that the General Assembly at its twenty-sixth session endorse the foregoing proposals and recommendations.

RECOMMENDATION OF THE CUSTOMS CO-OPERATION COUNCIL TO EXPEDITE THE FORWARDING OF RELIEF CONSIGNMENTS IN THE EVENT OF DISASTERS

(8TH JUNE, 1970)

THE CUSTOMS CO-OPERATION COUNCIL

DESIRING to contribute to the efforts made in the interest of humanity to assist victims of disasters;

CONSIDERING that the effectiveness of such assistance is dependent to a large extent on the speed with which it can be furnished;

CONSIDERING that the simplification and harmonisation of Customs formalities, by facilitating the crossing of frontiers, would expedite the forwarding of relief consignments in the event of disasters;

RECOMMENDS that Members should:

1. waive any economic export prohibitions or restrictions, and any export duties or taxes, in respect of goods contained in relief consignments destined to countries having suffered disasters;
2. accept at exportation, as a general rule, the written declarations made out by the exporters of relief consignments as evidence of the contents and of the intended use of such consignments;
3. take such steps as may be necessary in order that, on application being made by the persons concerned, the Customs authorities of the exporting country may be in a position to:
    - (a) examine, where appropriate by random checks, against a detailed list, the contents of relief consignments, and certify the results of this examination on that list; and
    - (b) where possible place such consignments under Customs seals;
4. facilitate as far as possible the carriage of relief consignments in Customs transit, with due regard to any action taken under paragraph 3 above;
5. allow admission free of import duties and taxes and free of economic import prohibitions or restrictions in respect of all relief consignments received as

gifts by organizations approved by the competent authorities, for distribution free of charge by such organizations or under their control to the victims of a disaster in their territory, in particular where such consignments consist of foodstuffs, medicaments, clothing, blankets, tents, prefabricated houses, or other goods of prime necessity;

6. facilitate the temporary admission, with conditional relief from import duties and taxes, of any equipment loaned free of charge to organizations approved by the competent authorities to be used under the control of such organizations in action undertaken to alleviate the effects of a disaster; and wherever possible not require security but be content with an undertaking given by the approved organization to re-export such equipment;

7. authorise, as far as possible, relief consignments to be cleared outside the hours and places normally prescribed, and, in such circumstances, waive, if possible, any charges for Customs attendance;

POINTS OUT that:

1. the term "disaster" shall be taken to cover both natural disasters and similar catastrophes;

2. the facilities provided for in this Recommendation shall not apply in respect of alcohol, alcoholic beverages or tobacco goods;

3. the provisions of this Recommendation shall not preclude the application of prohibitions or restrictions imposed under national laws and regulations on grounds of public morality or order, public security, public hygiene or health or based on veterinary or phytopathological considerations;

4. this Recommendation does not prevent the application of greater facilities which certain Members grant or may grant in future by unilateral provisions or by virtue of bilateral or multilateral agreements;

INVITES Members:

1. to approve without delay the national organizations which under paragraphs 5 and 6 above would be responsible for the receipt and distribution of relief consignments; and

2. to issue as soon as possible to the competent Customs offices such instructions as may be necessary to ensure, should the case arise, the immediate implementation of the provisions of this Recommendation;

REQUESTS Members who accept this Recommendation to notify the Secretary General of their acceptance, of the date from which they will apply the Recommendation, and of the conditions of its application. The Secretary General will transmit this information to the Customs Administrations of Members.

AGENDA OF THE MEETING

Thursday, May 20, 9:30 A.M. - 1:00 P.M.

1. Formal Opening: Honorable Lee A. DuBridge, Chairman

2. Welcoming Remarks: Honorable Joseph P. Alioto, Mayor of San Francisco

3. Remarks: Dr. Gunnar Randers, Assistant Secretary General for Scientific Affairs, NATO

4. Remarks: Dr. Charles F. Richter, Professor Emeritus of Seismology, California Institute of Technology

5. Address: Honorable Carlo Calenda, Minister Plenipotentiary of Italy

6. Remarks: Honorable Darrell M. Trent, Deputy Director, Office of Emergency Preparedness, Executive Office of the President

7. Address: Dr. Kazim Ergin, Turkey

8. Presentation on the Los Angeles Earthquake -- Seismological Effects: Dr. Clarence R. Allen, Professor of Geology and Geophysics, California Institute of Technology

9. Presentation on the Los Angeles Earthquake -- Physical Damage: Dr. C. Martin Duke, Professor of Civil Engineering, University of California at Los Angeles

10. Presentation on the Frontiers of Seismology -- Relevance to Disaster Functions: Dr. Jack Oliver, Lamont-Doherty Geological Observatory, Columbia University

Thursday, May 20, 1:15 P.M.

1. Luncheon Speakers: The Honorable John A. Volpe, Secretary of Transportation; Mrs. Shirley Temple Black, Deputy Chairman, U.S. Delegation to the Preparatory Committee, U.N. Conference on Human Environment.

Thursday, May 20, 3:00 P.M. - 6:00 P.M.

1. Working Group Sessions

Friday, May 21, 10:00 A.M. - 1:00 P.M. and 3:00 P.M. - 6:00 P.M.

1. Working Group Sessions

Saturday, May 22, 10:00 A.M. - 1:00 P.M.

1. Working Group Sessions (as needed)

Monday, May 24, 9:30 A.M. - 5:00 P.M.

1. Tour of areas of seismic disturbance

Tuesday, May 25, 10:00 A.M. - 1:00 P.M.

1. Remarks: Honorable Rogers C. B. Morton, Secretary of the Interior
2. Working Group Reports
3. Comment and Discussion
4. Closing Address; Honorable George A. Lincoln, Director, Office of Emergency Preparedness, Executive Office of the President
5. Formal Closing: Honorable Lee A. DuBridge, Chairman

OPENING REMARKS BY DR. LEE A. DuBRIDGE
May 20, 1971

My distinguished Co-Chairmen, Dr. Randers, ladies and gentlemen:

It is my great privilege to begin this meeting by presenting this message from the President of the United States (message attached).

President Nixon has expressed so very well what should be our goal at this conference: to collect, exchange and expand our knowledge of earthquakes and of what we can do about them. For earthquakes, like many of nature's catastrophic phenomena, are a common threat to each of our countries as well as a common concern to each of our professions.

Many years ago when I was a cub reporter for our small town newspaper, my editor conveyed to me the advice of all editors: Be sure your story tells the "who, what, where, when, and why" of your subject. Let me try this approach here.

Who are we? We are, first of all, human beings who, wherever we live, face to some degree the same threat, possibly rare but potentially catastrophic, of an earthquake. Like everyone else back home -- or here in this city -- we are possible victims.

We are, next, professional people from a variety of disciplines and occupations: academicians and scientists, government leaders and specialists, representatives of world and national relief organizations, members of industry and communications media. Some, like myself, are (or have been) a mix of several of these classifications. But we all have in common a concern with earthquakes -- their characteristics or consequence, their prediction or detection, the picking up of the pieces after a quake or the holding of the pieces together during one.

Cosmopolitan in our careers, we are no less so in our countries. This is truly an international -- worldwide -- gathering. We have come from the South Pacific, the Far East, the Middle East, the north and south of Europe, South and North America; from the tropics and the temperate zones, from islands and mainlands, from lowlands and mountainlands, from large and small, populous and not-so-populous countries. Whatever the geographic, topographic or demographic characteristics of our homelands, they have a susceptibility to earthquakes. For some this is a very real and ever-present danger; for others a more remote but no less horrendous possibility.

It is this common interest which answers the journalistic "what?" about this meeting. It is a gathering and a mix of disciplines, experiences, and ideas. It is a bourse, a marketplace, for the exchange of knowledge. As our busy agenda intimates, it will be a beehive to foster the cross-pollenization of the empirical and the theoretical, with the intended result a flowering of actions to reduce our common vulnerability to earthquakes and to increase our respective capabilities for coping with them.

This is not just another ritualistic conference to exchange technical papers and diplomatic pleasantries for their own sake. This is rather a working session designed to produce plans and projects and recommended actions for dealing with earthquakes.

As to the "where" of this international meeting on earthquakes our location could hardly be more appropriate, for a number of reasons. Many of our countries could be fitting scenes for such a conference. Among the members of the sponsoring Committee on the Challenges of Modern Society, the three co-pilot countries for the CCMS study on disaster assistance, Italy and Turkey and the United States, have all endured the destructive consequences of earthquakes more than once in recent years. We are met here in America because the United States is our host, and the President of the United States has been instrumental in inspiring and organizing this entire international approach to disasters.

We are here in California appropriately, and perhaps not a little tremulously, for this State is well known as one of the most quake-prone areas in North America. But California is also noted as one of the leading centers of earthquake research -- for which my California Institute of Technology can claim much credit, having initiated a program of seismological research some 42 years ago. And what more fitting site in California than San Francisco? This city is perched atop a notorious and ominous geologic fault which was the scene of one of the world's most unforgettable earthquakes 65 years ago. (I myself visited this city as a small boy with my parents a year later and saw the devastation.) Surely it is one of the world's most beautiful, most cosmopolitan, and , as I am sure our mayor will guarantee, most hospitable cities. And I should not need to remind you that San Francisco is also the birthplace of the United Nations.

The "when" of our conference is no less appropriate. Exactly one hundred days ago, this State experienced, in the Los Angeles area, a major earthquake in which scores were killed or injured and in which damage was measured in hundreds of millions of dollars. Its many aftershocks have been duly recorded ever since; perhaps the seismologists on our program will favor us with a special tremor to mark this occasion.

The timing of the conference is apt in a broader scope as well, for this planet has been going through a time of tremblors in recent years, perhaps a peak period in the Earth's seismic cycle. Worse, these past few years have witnessed several earthquakes not only severe in magnitude but catastrophic in consequences -- in Italy, Turkey and Peru.

This is also a time of dire predictions of cataclysmic quakes, particularly for California. And of course to seers of doom endemic to this area there is enough sound scientific evidence to justify rational concern. On a more optimistic note, this is a time, too, of increased knowledge of earthquakes and of ways to avoid or reduce their destructive effects, a time of growing awareness that such techniques and actions can and should by employed. And this is a time of never-greater opportunity for all nations to work together, so that these measures will be taken.

The fifth of the journalist's "w" words is "why." Why this conference? I need hardly remind you, the participants. And to some extent I have already answered this. But for the record, at least, I shall reiterate the officially stated objectives: namely, to

1. Provide a forum for an open and comprehensive exchange of information among experts on earthquake problems and the practical measures for mitigating the social and economic effects of major earthquakes;

2. Produce recommendations to governments with respect to the mitigation of earthquake hazards and development of preparedness programs for post-earthquake rehabilitation and recovery.

That, I believe, is a clear and succinct statement of our principal purposes here. But there is another to be noted: in a word, to "influence." All of those present are persons of some influence in their countries, their organizations, or professions; the type of people to implement recommendations. We have then a responsibility to exercise that influence in our various ways. What we produce here must go forth and be sold. Those preventive and remedial measures we judge to be proper and practicable we must convince our leaders to initiate and our societies to implement. Nor should we forget public opinion. We must make known our conclusions and our counsel to the people, through the communications media and through our own personal contact.

The bulk of our conference -- and our productivity -- will be in the four Work Groups, each consisting of presentations and discussions, varying in format to suit the participants and their topics. Three Work Groups dissect the subject of earthquakes somewhat sequentially. The first one deals with prevention and hazard reduction; it will be chaired by Mr. Aytun of Turkey. He is the head of the Earthquake Research Institute in the Ministry of Housing and Construction. The second group deals with relief organization and operation; Dr. Migliore of Italy will be its chairman. Dr. Migliore is the Director General of Civil Protection and Fire Prevention and has personally directed assistance operations at the natural disasters in Italy in recent years. Working Group III will examine rehabilitation and recovery; its chairman will be Mr. Stephen R. Tripp of the United States. For the past seven years he has been the Disaster Relief Coordinator in the Agency for International Development; he will be retiring shortly after many years of esteemed service to the United States. The "flesh and bones" of earthquakes treated by these three groups will be complemented by Work Group IV on the role of governments, universities and industry and volunteer organizations. The Chairman of this group will be Dr. Enrico Quarantelli of the United States; Dr. Quarantelli is the Co-Director of the Disaster Research Center at the Ohio State University. On our last day, we shall hear their reports, have our final say, and shape our recommendations.

Nature's upheavals are not confined by artificial boundaries. And neither should be our response. Our task is to make certain that the borders separating nations do not become fault lines deterring mutual assistance among those nations. International cooperation, in earthquakes as in anything else, should not be so earthshaking a phenomenon, after all. Your presence here proves that.

"It is a special pleasure to welcome to our country the delegates from all over the world who will be attending this important International Meeting on Earthquakes.

I find it personally gratifying that NATO's Committee on the Challenges of Modern Society, whose founding I urged two years ago, has in so short a time effectively responded to the problems of improving the quality of life for all peoples. It is especially to the credit of its members that, by directing its agenda to tasks of wide international significance, the Committee has stimulated participation in these matters by non-member nations.

Natural disasters have no national boundaries. If men are to cope with the threat of earthquakes and the tragedies they too often leave behind, it is imperative that all governments join in sharing ideas and resources freely and imaginatively.

I will be following your deliberations with great interest, with the hope that they may result in useful new advances for the good of all mankind."

RICHARD NIXON

SPEECH BY THE ASSISTANT SECRETARY GENERAL FOR SCIENTIFIC AFFAIRS OF NATO
GUNNAR RANDERS

It seems to be generally agreed, that San Francisco is a perfect city for a conference. I believe there is no less agreement about the special suitability of San Francisco for a conference on Earthquake Hazard Reduction.

There may be somewhat less agreement or perhaps I should day less understanding of why NATO as an Organization should play a role in organizing a conference on Earthquake Hazard Reduction. The general public ordinarily views NATO as a group of militaries watching the borders of Europe and the Atlantic Ocean. Few people have clear ideas about the daily tasks of the North Atlantic Treaty Organization. What probably causes a lack of knowledge or of understanding of NATO's tasks is perhaps the mistaken concept of NATO as a purely military organization. NATO is a defense organization, undertaking to defend the kind of life we have built up and want to maintain in the Western world. Defense involves a great number of other tasks than just military preparedness. Although agreement on a common military resistance against attack is basic, it is really the civilian aspects of NATO's work which have been the main achievement during the last 20 years of peace in the Western world. The daily political consultations among governments at NATO Headquarters in Brussels has been the main factor in maintaining peace for such a long time. The program of supporting scientific research and development in general, not specifically military research, is another indication of the peaceful and constructive activities of the Organization. It says in Article 2 of the North Atlantic Treaty that the member countries shall contribute towards the further development of peaceful and friendly international relations by promoting conditions of stability and well being. It was realized 13 years ago that the growth of science and technology is not only unavoidable, but also a necessary factor in order to create a high standard of living for a steadily growing number of people. It is interesting that as a result of this early realization, NATO has become one of the present days' strong bastions fighting for the support of science in all fields.

It is against this background that one must view the most recent task of NATO, the one which brings us here together today, namely the work to improve the human environment. In his address to the 15 Foreign Ministers in Washington in April, 1969, President Nixon urged the creation of a committee on the challenges of modern society, to explore ways in which the experience and resources of the Western nations could most effectvely be marshalled towards improving the quality of life of our peoples. On November 6, 1969, the NATO Council consequently created the CCMS.

It is probably unnecessary to remind anybody here of the problems of modern society. We encounter these problems every day in newspapers, in television programs, and not least in our own lives. Practically all these questions need national action taken by governments in the form of legislation or programs of improvement for their effective solution. However, some of them, for example pollution of the air and the sea, noise from aircraft, traffic safety, need a coordinated action by several nations at the same time. This means that some kind of international organization must be brought into the picture. A very usual first thought amongst most people is that in that case, the United Nations should be the organization. However desirable this may be in the long run, there are serious shortcomings, limiting the possibilities of the United Nations for this purpose. It may well be impossible to face the most urgent tasks in time, if we are to rely upon an organization of more than a hundred nations for taking action. The United Nations have amongst them a majority of nations which often have very different problems. For the moment some of those many nations even seem to consider the environmental activities of the West with some suspicion, feeling that the strict regulations facing industries and other polluters of the environment today, are measures which may hamper the rest of the world struggling to enter into the industrial era.

It is a geographical fact that for example, the cleaning up of the North Sea or the North Atlantic from oil spills does not vitally interest the countries of Africa and vice versa, and one could not expect rapid action on such urgent matters to be taken if all nations of the world are necessarily to be involved in each special case.

Finally, the real answer to the question of which international organization should be used for common efforts to improve our environment is that there has never been and that there will never be a question of one single international organization. There are so many pressing problems and so many different types of action to be taken, that no single international organization could possibly cope with them all. The question is therefore not which international organization should be the one to improve our environment, but what problem could each particular international organization manage to solve better than others. When this is answered, there will be tasks for all to undertake - and still more tasks looking for promoting agencies.

President Nixon and the NATO Council have given one answer to this question by establishing the new NATO committee, which has as its first and foremost task to induce action among the NATO countries. By action is meant specific undertakings that would affect the problems from which society suffers today, and not research and studies which, even if necessary and useful, do nevertheless require a long time, and which do not in themselves affect the problems. More than other international organizations, NATO is accustomed to action programmes, using the close contacts with the 15 member governments. As a typical example of such action I can mention the agreement among the NATO countries last November to prohibit future deliberate oil spills. Another example is the work to improve safety regulations for automobiles. A third is the attack on the pollution in the St. Lawrence River Basin in Canada. All the projects undertaken by the NATO Committee on the Challenges of Modern Society are being led by one NATO country, the so-called pilot country. This pilot country is responsible for the main drive behind each project, and uses its best national experts and organizations in cooperation with other interested nations. This project should lead to action-recommendations that are realistic.

Is Earthquake Hazard Reduction a problem of modern society? Have not earthquakes always existed? They certainly have, but the development of modern technology and big city communities affect the problem in two ways: first, the greater congregation of people and property, and the complex network of all amenities needed for life in big cities, make a modern society more vulnerable than before. Second, the possibilities of science and technology for preventive undertakings and for planning mitigation and relief in case of a disaster, are infinitely greater today than they were before. These modern methods and possibilities have never really been exploited systematically.

It is for this purpose that we are gathering here in San Francisco this week. The United States, as pilot country for the NATO Disaster Assistance Project, has realized the importance of systematic use of modern science and technology to avoid disasters in case of earthquakes. The pilot nation with its copilots, Italy and Turkey have already worked in a preliminary way during the whole of last year, and the conference here in San Francisco is meant to mark a decisive step forward, which should benefit not only the people living in California, but also those living in Europe, Asia and other parts of the world. The presence of numerous experts from outside the NATO group shows clearly how the matter is of deep concern to many countries, and that such countries realize the value of this initiative, so seriously undertaken by several nations with the same problem.

On behalf of the CCMS and the Secretary General, I want to express appreciation for the initiative taken, the work done in preparing for the meeting, and for the hospitality shown to all of us. It is my hope and belief that this meeting will be remembered as an important step in reducing earthquake hazards.

EARTHQUAKE DISASTERS - AN INTERNATIONAL PROBLEM

C. F. RICHTER

Towards the mitigation of the disastrous consequences of earthquakes, there could be no more promisimg a step than to organize an international exchange of experience and ideas.

Major earthquake disasters in any one region usually occur at intervals of many years; experience gained may be neglected and forgotten before the next emergency arises. Operation on the global scale favors more lasting preparedness, preserving what has been learned and applying it at each new occasion.

The purpose is partly served by the periodic international conferences on geophysics and on earthquake engineering, as well as by the work of subdivisions of the United Nations organization. That this is not yet sufficient is evident from the inefficiency of public response to earthquake disasters, in this country and elsewhere.

The usual official reaction to such disasters is to appoint investigating commissions. In some countries this has led to permanent research establishments, and consequently to continuous accumulation of knowledge with regard to earthquakes. Often, however, there is no substantial effect on society as a whole. The report of the scientific commission which investigated the California earthquake of 1906 is still one of the most important documents in seismology; but California businessmen and administrators ignored the obvious lessons of the disaster, and there was no constructive public action until after the earthquakes at Santa Barbara in 1925 and Long Beach in 1933.

Of late years reports have been prepared at considerable public expense, even when the participants were donating their services, and then largely ignored, as has happened in Alaska since 1964.

Following the San Fernando earthquake of February 9, 1971, there has been a rash of publicly appointed committees, some of them taking the time of research men away from investigation; it is rather doubtful whether there will be sufficient good results to justify the time expended.

It should be more generally understood that earthquake losses are largely unnecessary and preventable. In the whole of past history, something like 90 percent of the loss of life in earthquakes, and a major fraction of the destruction and economic loss, has been due to the failure of weak structures, such as would never be erected under any modern system of building regulation and inspection. This is particularly evident in the Mediterranean region and in the Near East; but the condition exists in many countries, even to a considerable extent right here in California.

Our February earthquake, however, has enforced a conclusion already indicated by earthquake effects elsewhere in the last ten years -- namely, that serious risk is not confined to superannuated buildings of inferior construction. Some buildings supposedly erected under modern standards have shown such damage as to set new problems for conscientious engineers. Studies now being carried out in California need to be correlated with recent experience in other countries.

An important function of a disaster organization is the dissemination of authentic information to the public, especially to administrators, executives, and other responsible persons. This is not easy. At a panel conference in Los Angeles following the February earthquake, several speakers outlined the general situation of risk and relief. Thereupon a gentleman in the audience rose to ask, in effect, "Why haven't we been told these things before?" In reply it was pointed out that the OEP and other organizations have distributed many thousands of pertinent informative pamphlets in this region. From my correspondence it is clear that anxious and well-intentioned citizens often have no idea where to turn for information.

A sad example of the low level of our standards of public education was provided two years ago by an utterly baseless scare about an impossible California earthquake disaster.

I am pleased that the subject of earthquake prediction has not been included in the program of this conference. A hope of prediction is often held out as a means to enlist support for an earthquake research program. This is misleading, whether intentionally or not, and ultimately it tends to damage relations between science and the public. Fortunately, procedures undertaken with the nominal purpose of prediction often have increased our actual understanding of earthquakes. Nevertheless, predictions are pernicious, even when they come from obviously incompetent sources; the possible evil effects of a false alarm coming from apparently scientific sources are even more serious.

Public obsession with prediction diverts attention away from the actually possible measures to diminish the damaging effects of future earthquakes. Conversely, the impossibility of exact prediction is used as an argument against any and all precautionary measures, ignoring the obvious fact that where earthquakes have occurred in the past they may be expected in the future.

Among students in science there is a catch phrase that "if you have no prediction you have no science." This is false, of course; those who speak and write thus should try to think more clearly about the meanings of the words they use.

To improve our information about possible future earthquakes, we need more thorough study of the geology and geophysics of earthquake regions. The occurrence of February 9 has again emphasized how far we are from a complete picture of earthquake possibilities in California.

ADDRESS BY HONORABLE CARLO CALENDA
MAY 20, 1971

It is a distinct honor for me to participate - as head of the Italian Delegation - in this international conference being held within the framework of NATO's efforts to meet the challenges of modern society and in answer to the authoritative appeal made by President Richard M. Nixon.

I welcome this opportunity to convey my greetings to the President of the United States of America and salute his outstanding endeavors on behalf of ever closer cooperation among the people of all nations, as leader of this great and generous nation. The challenges of our time and the innumerable problems modern society presents have given a new dimension to NATO and opened new horizons toward the possibility of achieving the peace for our world we all seek.

May I then, before giving you a technical exposition of Italy's seismological characteristics, convey my greetings also to the President of this international meeting, the Honorable Lee A. Dubridge and to the Co-chairmen, the Honorable Kazim Ergin and the Honorable Darrell Trent, as well as to the heads of all Foreign Delegations, observers, participants and representatives of world organizations present here today.

This meeting of the C. C. M. S. follows the one held in Venice by the same organization in 1970 on the problems of disastrous floods. The 1970 meeting's results may be defined as extremely satisfactory. We are certain that this meeting will not fail to achieve equally gratifying results.

Mr. Chairman, Ladies and Gentlemen, on our planet the earth, three vast sea basins may be distinguished for their natural characteristics and for the development of civilizations which around them have developed with the histories of large populations, the Caribbean, the Yellow Sea and the Mediterranean Sea.

In the center of the Mediterranean Sea, almost as a bridge between Europe and Africa, our country lays, Italy. It is included between 47 and 37 degrees of latitude North, and 7 and 19 degrees of longitude East.

Limited at North from the large arc of the Alps, Italy is surrounded at East from the Adriatic Sea, at South from the Ionian Sea and from the Mediterranean, at West from the Tyrrhenian Sea. Two major islands, Sicily and Sardinia and several smaller are also part of Italy.

During our congress the various groups of work will study the various matters included in the program with detailed and accurate analysis from the view point of geological, geophysical and seismical characteristics as well as the civil and social aspects of our populations and the organizations which are in charge of the provisions to be taken in the cases of seismic calamities to prevent at the maximum possible extent the human civil damages which from such calamities may derive.

It is my task to make a short synthesis of what will be better developed, in order to give an organic picture of the whole of the reports concerning the various matters.

I would like firstly to recall in a few words the geological origin of our earth because from it we may recognize the fundamental reasons which give to the earth the present tectonic characteristics and the inherent seismological activities.

If we could give a look to the surface of earth of 600 million years ago which is about the end of Archeozoic era, in the area presently covered by the Mediterranean, we would see a sea extending from Germany (Black Forest) to the African horsts. At the bottom of the sea at this moment huge phenomena are developing, such as the subsidence of areas with sinking bottoms (geosynclines), the rising of huge sedimentary masses (orogenies), the formation of magma pockets which gradually give origin to granitic horsts and to vulcanic activity.

The Paleozoic era begins, lasting 350 million years, during which the first lands which will form Italy start to emerge from the waters.

First some peaks of Sardinia and the main line of the Alps (Gran Paradiso, Mont Blanc, St. Gottard) while in the South the granitic masses of Sila and of Aspromonte take shape.

A further period follows of calm of endogenous forces, up to the beginning of the Cenozoic period, in which start those orogenic paroxisms which press and raise sedimentary masses of big thicknesses which make complete the backbone of the Alps system and make less deep the hollow of marine sedimentation of the Northern Apennines. Sixty million years ago started to take shape the land which is presently Italy.

In conclusion, to outline a geotectonic profile in broad lines, we may distinguish the crystalline chain of North Alps, to which the Southern Alps, of calcareous type, follow, the Northern Apennines covered by layers of clay flowing from the Tyrolean hinterland and superimposed to the original autotonous structure.

The Central Apennine has a structure completely different, as it is formed of layers of folds more or less regular which overturn towards East, while from Campania a calcareous structure begins.

In the South (Calabria and Peloritanian Mountains) the present mountain chain is originated by the dismemberment of the ancient crystalline horsts.

All the Tyrrhenian side of the Apennine Chain from Tuscany to Sicily is characterized from more or less volcanic activity. The seismic activity typical of Italy is the direct proof of the orogenic phenomena previously described.

If we exclude the Southern Tyrrhenian Sea, in which we may find focus depths up to 250 miles, earthquakes in Italy have origin in the crust of the earth, which has a maximum depth of 40 miles in correspondence of the mountain horsts.

The above mentioned area, beyond being affected by earthquakes with deep focus, shows vulcanic activity, and, alone in Europe, has tectonic characteristics similar to those of the Sunda Islands and of Japan.

In the Alps, in the Southern Apennines and in Sicily, the fact which gives origin to the shock at the focus is a fracture; in the Central Apennines phenomena of upraising at depth of 8 to 15 miles have been ascertained and in the Northern Adriatic Sea earthquakes have origin at the edges of the Earth's crust and their cause is the sinking of the Adriatic geosyncline. It appears that to the sinking in the areas of Northern Adriatic correspond surface upraising of the Apenninic chain parallel to the geosyncline.

Seismology in Italy is a very ancient science, and the care with which scientists of all periods have studied and described the seismic events makes possible to outline a history, which especially for the last 15 centuries is highly reliable; from this history it follows that with the exception of Central Sardinia, all the Italian Country is more or less affected by seismic activity.

The most affected areas are the East Alps and pre-Alps, the Central and Southern Apennines, Sicily; actually every year in one of these areas a seismic event happens of such intensity as to cause important damages and losses of human lives.

The urgent need exists therefore to provide suitable rules to allow an efficient defense against the dangers of such events.

Apparently, it may appear strange that this problem be still existing; already in 1783 for Calabria and more recently in 1860 for Northern Lazio directions were issued for antiseismic purposes. Back in 1909 at the time of the Messina earthquake the first methods of calculation of horizontal forces caused by such phenomena were developed, to check stresses on structures.

Studies were continued without interruptions and it could appear strange that seismology and seismic engineering be considered as a new matter of study.

However, today these matters have a new dimension particularly in view of the following:

1) The high density population (in average in excess of 200 inhabitants per sq. Km) which reaches in several areas very high values, as only two thirds of the national area are usable being the remaining one third mountains.

2) The need of developing industrial activities in the areas of lower economical level, which happen to be also those of more seismic activity.

3) The existence in Italy of building of ancient age and of historical premises which cannot be segregated as direct proof of the artistic and cultural development of the Country.

The problem therefore presents two aspects, one of them strictly technical and scientific, the other social and economical.

The social and economical aspect involves not only the provision of aids and measures which have to be provided timely, adequate to the local environment, suitable for the social and pysicological differences existing throughout Italy, and in the same time must ensure a fast return to the normal daily activities and the reinclusion of the affected population in the national life.

The immediate provision of interventions of first aid is today made with an high degree of efficiency, guaranteed from a unique Organization which takes direct care of the operations and coordinates possible actions by other organizations. The problems inherent to reconstruction and to the economic recovery are solved case by case by means of appropriate laws. The technical aspect has as scope the issue of regulations concerning not only the new buildings in seismic areas, but also the reinforcing of the existing ones in order to make them adequate to stand the seismic events. One side of the problem is the task of the seismologist, the other to the engineer, but the two are strictly interrelated, as the knowledge of the seismic phenomena must be such to allow the engineer to design structures adequate to stand the foreseable events.

A new type of seismology takes place, by which the earthquake must be studied directly at the focus, and mainly in connection to its surface effects.

This has been solved with a program of improvement of the national seismologic network, with the installation of a system of accelerometers, with the organization of mobile units to be used during periods of more seismic activity, and with a more accurate service of information and macroseismic surveys. In addition to the elaboration of the observed data, the studies of physical characteristics of earthquakes of close origin have been improved, and the preparation of seismotectonic maps and of the maximum expectable intensities is under way.

The first results achieved will be described in the various reports presented in the meetings of the groups of work. I would like to mention the preparation of the New Text of Seismic Rules which will replace the old Regulations more adhering to the requirements of the modern technique, which is based on the dynamic caracteristics of the various structures.

In closing, consent me to mention the fact that Professor Francesco Peronacci, Director of the National Observatory of Seismology of the Institute of Geophysics of Italy represents here today also the Seismological European Commission of the International Geodesic and Geophysics Union, with headquarters in Strasbourg.

May I also express my deep sympathy on this occasion - also on behalf of my government - to the victims of the disastrous recent quake in Turkey, once again so gravely tried by a natural disaster.

To the Mayor of this lovely city, the Honorable Joseph Alioto and to all San Franciscans, hosts of this meeting, the warm greetings of the Italian delegation as well as my own personal warm regards.

REMARKS BY DARRELL M. TRENT
MAY 20, 1971

Mr. Chairman, my distinguished Italian Co-Chairman, my distinguished Turkish Co-Chairman, honored guests, visitors and friends.

This is the best opportunity I will have to add a warm welcome to all of you who have come here to make this meeting a success, and to express my personal thanks to everyone who participated in the indispensable planning and preparation stages.

We come together basically as two groups. The scientists and engineers among us represent the fullness of our understanding of earthquakes as natural events, while the rest of us are mainly concerned with how governments can diminish the damage, destruction and deaths resulting from earthquakes when they occur. This conference gives us all the opportunity to work together, building on our combined experiences, continuing the search for new insights, and learning from each other as we go along.

My agency, the Office of Emergency Preparedness, has for years represented the President through his Executive Offices in providing Federal disaster relief to America's State governments, local communities, and individual citizens. We have learned much over the years about how to deal with natural disasters, but there is so much more to discover, to learn, to do. So we particularly welcome the opportunity to compare notes and benefit from the experiences of other nations in coping with these disturbances of the natural environment. We shall, of course, be especially interested in such topics as building codes and other aspects of advance planning, as well as in restoring local government, transportation, communication, health services and business operations of a community after it has been stricken.

I hope to learn much from you who are participating in this Conference. As a generalist and an administrator in the area of disaster recovery, I do not have the experience or expertise in the causes of disasters that many of you can offer. But I am learning from my exposure. This is my second CCMS technical conference. I had the privilege of studying flood control last October in Venice with our Italian co-pilots and other interested nations.

Last February, I flew to the Los Angeles area to aid in immediate recovery efforts from the earthquake that occurred in the San Fernando Valley. It is sobering to reflect that this temblor was considered "moderate," reading 6.6 on the Richter scale. Still, it caused 65 deaths, brought more than a billion dollars of destruction to property, and resulted in a major disaster declaration by President Nixon. The assistance from the Federal Government alone for relief and restoration in the affected area will cost more than $400 million.

Luckily, the tremors occurred early in the morning, when most of the residents of the San Fernando Valley were asleep and did not reach peak intensity in the more densely settled parts of the county. The epicenter was well removed from the populated areas, and the greatest damage was on the outer fringes of the built-up sections.

As it turned out, the fault which developed the San Fernando earthquake was a relatively small one which had been dormant for thousands of years. Other fault lines in the vicinity would have been considered more likely indicators of an earthquake location. A seismic map of Los Angeles County identifies some of the major fault lines in the area, which could be particularly troublesome in the future.

The Office of Emergency Preparedness has initiated a number of major studies of the Los Angeles experience in cooperation with other Federal agencies and private organizations. We hope to use the results of this analysis to improve our preparation for mitigating earthquake damage in the future.

Since the turn of the century, over three-quarters of a million people have died in 30 major earthquakes in various countries. In the United States alone during that time, there were five quakes more powerful than the recent Los Angeles temblor. Three have now become most famous as a data base in our studies. In Anchorage, Alaska, in 1964, and in San Francisco in 1906, each registered energy releases about 900 times the intensity recorded for last February's San Fernando earthquake. Even so, the three together caused fewer than a thousand fatalities.

I hope we have been able to structure this conference so that everyone will be able to participate in a comprehensive exchange of ideas and information.

I particularly want to thank the Italian and Turkish delegations who are co-pilots of this conference and have helped make our meetings possible.

Whether you come here today as a natural scientist or an engineer, a diplomat or a government executive, a sociologist or a relief expert, this conference offers great opportunity to exchange information, to compare recovery plans and procedures, and to arrange for greater future cooperation between nations. By pooling our interdisciplinary skills and international energies, we can work together to diminish the damage and destruction in future earthquakes.

Thank you for coming.

THE ROLE OF SCIENCE IN PROTECTING MAN AGAINST EARTHQUAKE DISASTER

KAZIM ERGIN
(Technical University of Istanbul, Turkey)

Seismologists all over the world have been studying earthquakes to get a better understanding of this natural phenomena, especially since the turn of this Century. But the greatest advances were achieved during the last decade. All available modern methods and techniques are being employed in solving problems related to earthquakes which could in the end, help to protect man against it. By gathering a large amount of data through systematic observation and by analysis, evaluation and interpretation of them, we have come to a state of knowledge whereas we can plan, design and build structures that can resist and survive large and destructive earthquakes. An excellent case history is provided by the recent San Fernando earthquake of the Los Angeles area. The damage done by this shock is small when we compare it with the amount of damage observed by some other recent earthquakes of similar magnitude that occurred elsewhere.

In many areas the intensity and acceleration of a strong earthquake are determined through visual inspection of the damage. For a sound engineering practice much better data are needed, which can only be obtained by suitable strong motion instruments. In many countries, including many in Europe, there are very few of those instruments in use. Establishing a well-planned network of strong motion instruments might be considered one of the items of an international project to be taken up by CCMS. Whenever I speak about the question of earthquake resistant buildings I always think of the problem of designing simple small houses that could withstand earthquake forces. This type of housing is needed in rural areas of most of the earthquake-prone countries. Building materials could be selected or manufactured according to the supplies available in a given region. This conference could emphasize these problems and encourage research on the international scale.

As a result of the advanced level of our knowledge today, the seismologists have been seriously considering predicting earthquakes. There is already news of some successful prediction and research in progress.

Earthquakes have occurred where no such events were known before. Such observations could be correlated sometimes with the injection of large amounts of water deep underground and in other cases with the detonation of atomic bombs or with filling with water of large dams. All these observations of man-made earthquakes lead seismologists to think that perhaps the energy stored within rocks could be released by controlled amount in areas of large destructive shocks and thus prevent the loss of life and property. This type of effort could eventually make the control of earthquakes a possibility.

All these results of the scientific endeavor well known to seismologists, particularly to California seismologists, are excellent examples of how findings of pure and applied scientific research can be channelled into practical forms and thus science can be put in service for man's protection against natural disasters.

What I have tried to say up to this point summarizes very briefly what can and should be done to minimize the hazards of earthquake disaster. In many earthquake zones of the world, the protection measures are far from adequate and when an area is stricken by a severe shock the whole scientific achievements are just phoney stories to the person involved. He wants immediate rescue, shelter, food and a helping hand. I cannot find words to express the importance of an alert emergency organization. During some recent earthquakes in many parts of the world we have observed that shortcomings in emergency measures have increased the death toll. It is our task to see to it that earthquake countries be better prepared to meet the challenge of disasters of that kind in the future. I hope that some practical and useful resolutions on this humanitarian aspect of earthquakes may come out of this conference.

In Turkey we have had a destructive earthquake every two years or so since 1939. During this period tens of thousands of people lost their lives. In this period of intense seismic activity, geologists, seismologists, civil engineers and government officials have learned a great deal and become really interested. This interest was exhibited during the Gediz earthquake of March 1970 which was studied by so many geologists, seismologists and particularly engineers.

Before concluding, I would like to mention the effort of UNESCO to support the seismological development in many countries through which more efficient data were collected and acquired knowledge was disseminated to countries which need it.

REMARKS BY US SECRETARY OF TRANSPORTATION
JOHN A. VOLPE

I appreciate this opportunity to address your international meeting on earthquakes. And being well-acquainted with NATO's committee on the challenges of modern society, I am sure that your meetings and deliberations here will be meaningful and worthwhile. I had the honor of presenting my country's position on intentional oil spills at sea at a CCMS Meeting in Brussels last November. And my Department has co-ordinated -- with CCMS co-operation -- the signing of agreements with West Germany, Japan Italy and the United Kingdom concerning experimental safety vehicles in an effort to cut the worldwide toll of highway deaths.

So I am certain that this open exchange of information -- and the recommendations that will be made -- will do much to mitigate earthquake hazards and improve preparedness programs for rehabilitation and recovery.

Like any natural disaster, earthquakes strike a sudden and destructive blow. Their devastation -- despite any amount of preparation -- produces emotional and physical problems that can be overwhelming.

This fact does not diminish the need for preparation, however. It strengthens it. It challenges us to plan better, to build better, and to continue the search for new methods of recovery. I am pleased to participate in that search at this meeting.

In transportation, at least, the key to recovery is quick action to repair the system so that it can serve others. Our plans for reconstruction must be fast and orderly. For it is the highway, the railroad, the airplane, and the ship that lead to hospitals, supply depots, and rescue centers.

Today is the fifth day of National Transportation Week which started May 16. In the last 108 hours I have visited eight cities to talk about transportation -- and to view various parts of the system in operation.

I have seen congestion beyond belief. And I have seen some of the solutions -- low-emission buses, a new airport control tower, new high-speed rail systems, and this afternoon I will ride on the sparkling new bay area rapid transit system.

But one of the most significant events of the week for me occurred in Denver. There I saw heavy duty army helicopters evacuate "victims" from a simulated highway accident. As those giant helicopters gingerly lifted patients into the air, my mind turned to today's speech and this meeting.

Of all aspects of transportation, none is as important as the saving of lives. And in the final analysis, the primary goal of emergency preparedness is to prevent death, injury, and destruction. We must never lose sight of that fact in the search for better disaster preparation.

In the Department of Transportation, emergency preparedness is an extremely important function. This Nation is covered with highways, airports, rail systems, harbors and ports. Almost any and every natural disaster effects one or more of these modes.

Fortunately, we have a strong internal organization in the office of emergency transportation and the regional emergency transportation coordinators. We are in the process of issuing a departmental order which states the disaster response policies and objectives of all segments of the Department. Each region has prepared and published, or is preparing to publish, it's own regional emergency transportation disaster plan. They outline a coordinated federal transportation response to any disaster situation.

Our OET Office is doing a fine job. Here in San Francisco, Admiral Whalen and Captain Peak of the Coast Guard are the regional coordinators. Captain Peak is moving down to New Orleans soon where I'm sure his California experience will be of great benefit -- especially during hurricane season.

There really is no substitute for experience in handling natural disasters. Certainly we in the Department have learned a great deal with the Alaska and California earthquakes.

Although we're now trying to sell the Alaska railroad for economic reasons, we're quite proud of the way it came through the Alaska earthquake on Good Friday in 1964. The railroad suffered damage to track, roadway, bridges, buildings, rolling stock, motive power, docks, and equipment. Repair costs totalled nearly 27 million dollars.

Yet less than a month after the quake, the Alaska railroad was hauling supplies through the wilderness from Anchorage to Whittier.

I think you might be interested in one dramatic bridge story, as told by Edwin Fitch in his book, "The Alaska Railroad." At one point the only bridge between Whittier and Anchorage was about to collapse from the force of tidal waters against the piers and abutments. It was decided to weight down the bridge with gravel-loaded hopper cars. In spite of the obvious risk of losing both cars and bridge, the attempt was made and it worked. Badly needed supplies were later moved across the bridge.

One of the railroad's most frustrating experiences was the scrambling of paper records and supply inventories. This seemingly insignificant item made recovery and reconstruction much more difficult. In areas with a high likelihood of natural disaster, internal security can be just as important as structural considerations.

The Alaska earthquake also taught some valuable lessons to the Federal Aviation Administration. The Anchorage International Airport tower collapsed; its instrument landing system stopped due to underground cable damage; its runway and approach lights were partially destroyed; and the Weather Bureau facilities were totally demolished.

Yet service continued almost immediately and air safety was insured. Two radio technicians set up shop in a DC-3 which had escaped damage -- and turned it into a temporary control tower.

This incident points up one of the outstanding qualities of aviation in time of disaster: Flexibility.

Most transportation systems depend on fixed guideways -- either concrete highways or steel rails. And these are often the first facilities to be destroyed even ports and harbors are closed by most natural disasters. The one avenue of travel that usually always remains open is the sky.

In any case, I urge this meeting to fully consider the importance of aviation in disaster assistance. Especially the potential of helicopters, and vertical and short take-off and landing aircraft. Most of us are familiar with the helicopter's capabilities. And the V-STOL aircraft are fast becoming a reality.

Development of V-STOL is lagging at this time because of the apparent lack of commercial support. I have no doubt, however, but that V-STOL development will continue and I urge you to consider its application to disaster relief.

One of the most bewildering aspects of this problem is the absolute vulnerability of transportation systems -- highways especially. In an earthquake, the mightiest of bridges and the thickest layers of concrete often crumble like stale cookies. In the Alaska quake, almost every bridge in the area was destroyed.

It is estimated that when total reconstruction work there is finally completed, the cost will reach 65 million dollars.

Here in California -- in Los Angeles -- it is estimated that over 25 million dollars will be needed in highway repairs. To date, relatively little repair work has been completed. This is because much of the damage -- some 9 million dollars -- was on active construction projects where legal questions must be resolved.

The California Division of Highways does not have an "Act of God" clause in its contracts. Consequently, contractors are legally responsible for repairing the damage. Unless this problem is solved, we cannot appropriate any funds to cover repair costs.

Aside from this stumbling block, however, repair actions have been swift. Within 13 days after the quake, we had concurred with Governor Reagan's letter requesting federal funds to repair the damage.

But no matter who pays the bills -- and ultimately we all do -- replacing highways and bridges is expensive. We must continually seek new methods of construction specially designed for earthquake areas.

I hope I haven't dwelled too long on our own problems. Transportation is a resource. It is a tool for disaster relief and it should be considered in that perspective. Our Office of Emergency Transportation is primarily concerned with coordinating transportation relief operations.

We want to help in any way we can -- rescue, emergency medical relief, evacuation and relocation, supply and any other appropriate area.

In conclusion, let me make the following observations. First, although the problems are severe, they can be overcome.

Second, although transportation is extremely vulnerable, it also offers great potential for emergency relief.

Third, we can all learn a great deal through the international exchange of ideas.

Fourth, considerable emphasis should be given to transportation planning and how it relates to other disaster problems.

And fifth, the U.S. Department of Transportation wants to do all it can to help.

Please consider these factors in your deliberations during the next five days. The conclusions you reach -- and the recommendations you develop -- are among the most urgently needed achievements today. And I am certain that all Nations will benefit from your collective thinking.

Thank you.

#######

REMARKS BY SHIRLEY TEMPLE BLACK

Thank you.

Sharing a podium today with Secretary Volpe recalls the time several years ago when we were in a group fishing off the Coast of Hawaii. Our boat-to-shore telephone brought a call from Washington asking me to serve as a U.S. Representative to the 24th General Assembly of the United Nations. It was a moment of great excitement for me, and satisfaction which continues to this day. But it ruined the fishing for Secretary Volpe, as we put away our poles and talked international talk.

And here we are today, still minus the poles, and still talking international talk. Lucky fish.

When this meeting's General Director, and my esteemed friend, Darrell Trent first proposed that I speak here today, my immediate reaction was, what on earth could I contribute of real substance to the deliberations of such an illustrious group of scholars, scientists, and specialists in the precise discipline of earthquakes.

To be sure, I, among others, was born on the San Andreas Fault, I live on the Fault, and with a little luck will die on the Fault, hopefully of natural causes and not as part of a natural disaster. I was brought up to regard a 21-foot displacement of the earth as the order of things.

As you all well know, California is hit by thousands of shocks every year, 500 of which are large enough to rattle the dishes and many of which can throw down the neighborhood school in a heap of rubble. Every 50 years we seem to have produced earthquakes of really destructive magnitude.

Way back in 1769, when Gaspar de Portola was beginning his northward trek which resulted in the discovery of San Francisco Bay, he was camped on the Santa Ana River. A violent quake shook the ground, reportedly threw the river up out of its channel, knocked men and horses to the ground. Witnessing this phenomenon, Portola, with disguised blasphemy, named the River "The River of the Sweetest Name of Jesus of the Earthquakes."

As a matter of fact, earthquakes in my home state are so common that anyone who follows the newspapers can fancy himself an expert on the subject. Magnitude numbers are repeated and compared like so many shoe sizes. But few people really know much about the origin and nature of earth-shocks, and thus the barest knowledge is soon converted into an authority.

Early peoples believed that earthquakes were caused by whatever or whoever was supporting the earth. The Algonquin Indians of North America thought quakes were caused by the slow steps of the giant tortoise who carried the world on his back. The Musselmen of Constantinople thought quakes were caused by the buffalo who supported the world on his shoulders shifting his weight from one foot to the other... The Masawahilis of East Africa devised a more complicated solution. In the universal ocean swam a fish called the Chewa. It carried on its back a stone, upon which stood a cow who balanced the earth on one of her horns. When the cow became weary and shifted the load to the other horn, there was an earthquake.

One of the world's eminent scientists, Aristotle, proposed that earthquakes were caused by extra quantities of air which entered the caverns and hollow passages which riddled the interior of the earth, and which then shook the earth in their attempts to escape. Apparently this theory was regarded as a logical explanation well into the 1700's.

The very worst culprits are those who rattle off poorly remembered stories, and half-baked statistics, and so I will resist the temptation here.

It is obvious, however, that if we in California -- and I speak of the general public of which I am a member -- if we are so exposed to earthquakes, and so drenched in reports about them in press, radio and TV, and yet remain so ill-informed about their imminence, their nature, and what can be done about them, what are the circumstances in less fortunate and less informed areas of the world? What of the Andes villages, what of rural Turkey, what of bays and oceanic islands exposed to the silent assault of sea waves from sub-oceanic quakes?... Where are the mechanisms to predict, to warn, to instigate the disastrous consequences?

Is it indeed the fate of particularly the developing areas of the world to persist in a state of relative ignorance, terror, and helplessness in the face of such national disasters?

And to compound the problems, demographic trends are working against a solution. One hundred years ago 85% of the U. S. population lived in rural areas, separated from one another, minimizing the immediate effect of an earthquake disaster. Today the situation is reversed. Eighty-five percent live in urban areas, clotted together, potentially magnifying the effect of any disaster which strikes.

In developed nations, our technical powers of predictability are constantly improving. Like chasing a gold vein in the California mountains the odds against complete success are monumental, but the potential rewards are so great we can't help trying. And lucky for us we do. Our structural engineering is constantly giving better recognition to the safe way to select a site and to build a building. Political decisions are being made to close and abandon public buildings which are hazardous, as in recent California decisions regarding schools. But how does our knowledge, or scientific ability, and our experience, whatever it is, become an asset to less-fortunate people elsewhere?

True, we are working hard to design buildings that will withstand shock and after-shock, and water, gas and electrical distributions to minimize hazard and maximize protection. But where does this leave developing nations exposed to the same relentless tides of population movement, as they are, and without the sophisticated engineering and humanitarian resources which are our good-fortune?

In my work with problems of the human environment at the United Nations, we devote our attentions to disasters of both natural and human origin.

Here today, your concern is with disasters of only natural, not human origin. Pollution is manmade, slow to be recognized, slow to cure. Earthquakes are made by nature, dramatic and powerful, quick to occur, and demanding an immediate response.

Whatever the origin -- nature, or man, the results are measured in terms of human anguish and practical losses for mankind. The same sword of Damocles hangs over us all.

In this context, United Nations work in the Human Environment, of which I am a part, must be intimately understood in what you say and do at this NATO-related conference. Quite unofficially, I would like to share with you some information and note two points of concern.

Five months ago the U.N. General Assembly brought up sharply by the Peru earthquakes and the disastrous typhoons in the Philippines and the Bay of Bengal, adopted a milestone resolution #2717. Not only does this resolution appeal to the humanitarian instincts of member states and specialized agencies for a wider base of emergency assistance, but it instructs the Secretary General to develop recommendations, for presentation to the General Assembly convening this September, for improvement of disaster assistance in general on an international basis.

The study requested of the Secretary General involves technology and scientific research to identify the causes and early manifestation of impending disasters. Pursuant to this part of the resolution, the Secretary General is studying the feasibility of setting up a global natural-disaster early warning system.. Such a system would be designed to provide warning against earthquakes, volcanic eruptions, floods, tidal waves, typhoons, other severe storms and similar phenomena.

The proposed system would build on existing monitoring and data collection networks, such as the World Meteorological Organization's World Weather Watch and the Integrated Global Ocean Station System. It would also embrace the latest developments in satellites and aircraft remote sensing, the establishment of monitoring stations for earthquakes along known land faults, the emplacement of devices on volcanoes to monitor their activity,... and the development of ground-based computer systems to exchange environmental data with satellites and aircraft. For the immediate future the Secretariat envisions that the center of this activity will be the World Meteorological Organization.

In addition, a program to coordinate research on earthquakes and volcanoes is also contemplated, probably under the direction of UNESCO. Such a program would be aimed at eliminating duplication of effort and channeling financial resources into the most promising and needed areas of research.

As you may already know, UNESCO has given and will continue to support the work of the international seismological center in Edinburgh. It also plans to promote and assist regional seismological centers, especially in South America, East Africa and Southeast Asia. Over the next year, missions of experts from UNESCO will be sent to the principal seismic areas of the world to advise seismological observatories on improving the quality of data supplied to regional centers, and to Edinburgh.

In addition, UNESCO plans continued research into past earthquakes, especially in the Middle East, East Asia, and South America, and will produce regional earthquake catalogues compiling historical and instrumental data.

All in all, a very promising statement of program, I'm sure you will agree.

Particularly when the total budget for 1971 and 1972 for the entire program just enumerated is a slim $52,000.

Speaking practically, the program and the budget seem a real mismatch.

This is the first major concern, to which I made reference earlier.

The second concern:

In Spring at Geneva, our U.N. committee worked long and hard on early warning systems for natural disasters.

The Secretariat's report, which is being prepared with assistance from experts of the Smithsonian Institution, will be submitted to the 26th U.N. General Assembly, and is expected to receive affirmative action.

I urge that whatever steps you take here in this Conference will carefully weigh what the U.N. is doing, and intends to do, so that you will not arrive at an unnecessary duplication of effort.

Forgive me if I intrude slightly into your speciality.

Let's take a trip.

If we begin in San Francisco and reach southward we pass Mexico, Central America, Peru, and Chile. Swinging westward is the arc of New Zealand and Fiji, then up through the Solomon Islands, New Guinea, the Phillipines, Republic of China, and the Peoples Republic of China. Then onward over the top of the Pacific, pass Japan, Kamchatka Peninsula, the Aleutians, Alaska and back down the western shore of Canada.

This is the world's most active earthquake region, the famous fiery girdle of the Pacific, surrounding the great ocean with an almost uninterrupted series of volcanoes and earthquakes. It has been estimated that seventy-five per cent of the shocks of high magnitude in the first half of this century have occurred in this area. This is a sizeable percentage of the million earthquakes which the earth experiences every year.

Any system of scientific reporting, analysis, and prediction requires a coordinated effort among all these nations. Any system of humanitarian response to help mitigate the effects of natural disasters should include all nations on that fiery girdle.

Yet, in the case of the Peoples Republic of China UN efforts to suggest an international global earthquake system, may be hampered by history and politics of the region.

Of course, the Peoples Republic of China is not a member of the U.N., although I, among others, have strongly urged her admittance, and her incentives to cooperate on earthquake problems in the fiery girdle are understandably unclear.

By the way, I'm told that the first device to measure the strength of an earth tremor, and the direction of its epicenter, is from the Han Dynasty in China. This devise consisted of a bell with eight dragons, each of which faced a different direction, and each with a ball in its mouth. Any shock of a certain strength made the ball fall from the jaws of the dragon facing the direction from which the shock came.

Ping-pong balls, or brass earthquake balls, perhaps my comments will dramatize some of the delicate and important problems that confront the international effort of the U.N. in disaster warning systems.

Ladies and gentlemen, I commend you for your concern and extend you my sincere wish for accurate predictions, and effective relief for neighbors less fortunate than we.

Above all I appreciate your invitation to be your guest.

I thank you.

REMARKS BY SECRETARY OF INTERIOR MORTON BEFORE THE MEETING ON EARTHQUAKES

Dr. DuBridge, Mr. Lincoln, Distinguished Co-Chairmen, Ladies and Gentlemen :

It is an honor and a pleasure to be with you today and to participate in this international meeting on earthquakes.

I am here in a dual capacity: as an emissary of President Nixon and as head of a concerned department of the United States Government.

In that first role, I have the honor and pleasure of conveying to you all--our friends from abroad and our own countrymen--the congratulations and thanks of the President of the United States.

We are witnessing, I believe, a renaissance of man's interest in his natural environment. He is showing a new awareness that his earthly birthright is threatened as never before, and a recognition that he must act to protect it. For therein lies his own survival in the never-ending strife of man versus nature. I can assure you that this awareness--this responsibility--is shared fully by President Nixon.

He has established within his own Executive Office the Council on Environmental Quality, which recommends national policies to promote the improvement of our surroundings, especially the preservation of those natural resources we take for granted but cannot survive without.

Two other major instruments have been established during President Nixon's Administration to cope with today's and tomorrow's environmental problems: the Environmental Protection Agency and, in the Department of Commerce, the National Oceanic and Atmospheric Administration. These have served to combine and strengthen previously divided operations. Furthermore, the President has just recently proposed a far-reaching reorganization to centralize Federal environmental programs within a new Department of Natural Resources.

The President's concern with environmental matters is certainly not limited to the threat of "creeping" disasters such as those caused by pollution or erosion or waste of our natural resources. The calamitous occurrences of concern to you have been faced head-on by his Administration. Witness the Government's response after Hurricane Camille in 1969--including President Nixon's personal visit to the disaster area.

Witness the aid provided to the victims of the East Pakistan cyclone and Peruvian earthquake. Mrs. Nixon's visit to Peru reflected the deep concern of the President and of the United States. Witness the new Disaster Relief Act of 1970, which he signed into law on December 31. Witness the record outpouring of aid in 1969, when he declared 29 "major disasters," enabling use of his Disaster Fund. From within his Executive Office, the Office of Emergency Preparedness coordinates the Federal response to natural disasters. Assigning this function to the President's Office achieves timely and efficient coordination of the dozen or so Federal agencies involved in rendering disaster relief and recovery.

And your work at this conference can yield recommendations on actions to reduce and overcome the effects of earthquakes which will have a receptive audience in the White House.

Through the efforts of those of you from other nations, I trust that your governments will be no less alert to these dangers and no less determined to act in the manner you have urged.

I mentioned that I was here also in another capacity, that of Secretary of the Interior. Certain kinds of disasters--earthquakes among them--are very much my department's concern. I am proud of the contribution made by the men and women of the Department of the Interior to man's understanding of earthquake vulnerability and potential and to man's efforts to withstand earthquake effects.

Within my department, the U.S. Geological Survey carries out extensive research programs dealing with crustal studies and earthquake fault mapping.

Under the direction of the Bureau of Reclamation, we are also studying the potential effects of earthquakes on major irrigation structures such as dams and aqueducts. This work of the Interior Department, done in collaboration with studies by other Federal Departments, State agencies, and universities, makes for a well integrated program aimed at coping with one of the great hazards of nature--earthquakes.

In summary, your efforts here during the past few days represent the kind of international cooperation we must have if we are in fact to succeed in mitigating the very grave hazards associated with earthquakes and with all types of natural disasters.

The results of this conference will show that you have, in fact, achieved no small measure of success in accomplishing what you set out to do.

I congratulate you and encourage you to continue in this most important effort.

REMARKS BY
HONORABLE G.A. LINCOLN

Honorable Chairman, distinguished co-Chairman, ladies and gentlemen, all of you who have gathered here in a great international endeavor, seeking ways to help people against the most disastrous of nature's phenomena--the earthquake.

Speaking for our President and our Government, I congratulate you on the progress you have made here and the promise of future advance.

My Office did arrange this meeting. It is appropriate to express our appreciation, in which I know you will all join, to Dr. Lee DuBridge for being our conference chairman, to Professor Randers for this and other great efforts on behalf of the NATO Committee on the Challenges of Modern Society, and to Minister Calenda of Italy and to Dr. Ergin of Turkey for serving as co-chairmen from our co-pilot countries. I do state personal thanks to my Deputy Director, Darrell Trent, as co-Chairman and Executive Director of this conference, and to all those who worked with him. We especially thank the members of foreign delegations who have traveled far to contribute to this effort. We thank all participants. Your experience and expertise have been the essential inputs to progress toward our conference objectives.

You have made great progress in your discussions of the last few days. That progress is recorded in the reports we have just heard. Much of the progress is due to a special characteristic of this meeting. This is the first time--so I am told--that experts from across the wide range of disciplines and human endeavors which are needed to deal with earthquakes have in fact met, in an international meeting, to grapple with the earthquake problem. You here are scientists, engineers, public administrators from all levels of government, disaster relief specialists, and representatives from universities and from industry, all applying your collective expertise to the earthquake hazard. You here are the standard bearers in the effort to help release man from one more of the ills to which he is vulnerable--the devastation of earthquakes. If any proof of this is necessary, the current calamity in Turkey is again proof beyond measure.

Certainly all here join in an expression of sympathy to our Turkish colleagues for the losses of life and homes from last week's earthquake in that country.

Earthquakes can be so destructive and, to their victims, so overwhelming that they have similarities to the threats and destruction of war.

True, very serious earthquakes are relatively rare. But seismic activity seems to have increased in some parts of the world recently. We think of the two latest major earthquakes in Turkey--one last weekend--and of Los Angeles to the south of us. There are earlier earthquakes to which we should also look for sobering lessons.

In west-central Turkey on March 28 last year, for example, an earthquake totally destroyed 28 villages, and left in ruins 80 percent of the Town of Gediz. The grim toll in people: more than 1,000 killed; 3,000 injured; 80,000 homeless. The earthquake which struck Peru on May 31--almost exactly one year ago--was the worst in history in terms of recorded death and destruction. Affected were 152 principal cities and towns. The human toll: nearly 67,000 killed; more than 143,000 injured; 500,000 homeless. Nor should we of the United States forget what happened in Alaska in 1964 and here in San Francisco in 1906.

The earthquake is a natural force which can strike people and communities widely and without warning. But individual people and communities and governments can take forehanded action to lessen the death and the destruction, and to snap back after the disaster occurs. Earthquake preparedness needs to be a central and pressing concern. We have been assembled here to discuss how to better that earthquake security.

Some of the things which can be done do not require that we be scientists. I understand a distinguished scientist addressed you a few days ago saying that a practical approach, easily understood by everyone, is to build your houses stronger.

One of the objectives of this meeting has been to increase the attention of experts, of governments, and of the public in general, toward the earthquake hazard. One of the sounder principles of human affairs is that, if people and their organizations can be brought to understand and focus on a problem, progress will be made in doing something about the problem.

My Office has responsibility to President Nixon for coordinating and directing our Government's program for federal help in case of major natural disasters. That program has long emphasized crisis assistance, relief, and recovery in support of our state and local governments. But the program has also by law a mission of preparedness for disaster. We have in President Nixon's Administration been placing increasing emphasis on that preparedness mission. In fact, the term "disaster program" is somewhat of a misnomer. The total federal program is more correctly a major "emergency" continuum from preparedness through crisis and recovery.

The first point that comes through strongly to any of us who think about the preparedness problem, whether we be scientists or laymen, is that each individual has a personal responsibility for himself and his family. The next point is that disasters, even large earthquakes, happen locally, and hence local government and local organizations receive the initial impact. They have the initial responsibility. But people need to be told the nature of hazards and their possible effects and how best to prepare.

The national government, wherever it is, also has a responsibility. It has been often suggested to me, by the way, that one of the major responsibilities of government is the prediction of potentially disastrous natural phenomena. I think most of us can agree with this view, as a general principle. In fact, we have become quite scientific in predicting some natural occurrences such as huge floods and hurricanes. But prediction is of only limited assistance if there is not a warning system and the individual has not been prepared to react. Some of you here who are scientists will some day participate in much more accurate predictions of earthquakes. But those predictions will be of limited usefulness if the people in the earthquake-prone areas have not prepared and as a result, for example, all the houses fall down from the effects of only a moderate earthquake. We must also acknowledge the costs and difficulties of stronger construction. The problem is not easy.

I do here take a few minutes to cite two examples of preparedness action.

There is a great need for a capability to handle large numbers of casualties quickly. Part of that readiness is an information system as to where casualties can be cared for. An excellent example is the emergency communications system developed by the Hospital Council of Southern California which proved invaluable in the recent earthquake there. The intercommunication among the hospitals and with their ambulances permitted the directing of ambulances to those facilities most capable of providing needed care; the communications system provided for dispatching medical personnel to those areas where they were needed most, and for calling for supplies from outside sources. This is an excellent example of needed local initiative which can well be copied and expanded.

As another example of action, I turn to one of the elements of the study program concerning disaster preparedness which my agency is sponsoring. Analyzing the earthquake preparedness problem, it seemed apparent that people, agencies, and governments prepare best if they have a specific scenario, in as much detail as possible, of what they are preparing against.

We have recently launched on an eight-month study being conducted by the National Oceanic and Atmospheric Administration of the Department of Commerce in close collaboration with my agency. Put simply, we are going to seek to define what would happen, and what the problems would be, in case of the repetition of a massive earthquake where we are now meeting.

Using data from the recent Los Angeles earthquake and other data, we will assess earthquakes in the magnitude of 8.3; 7.5; and 6.5 on the Richter Scale, and will include an appraisal of damages and of interruptions of services.

We have assurances of assistance for this study from all federal agencies associated with earthquake problems, as well as from scientific and engineering establishments, and from private individuals and universities.

We hope to learn a great deal more about what a massive earthquake would mean and require here in the United States. But even more important, we are certain we will provide a much better data base for preparedness of federal agencies, of state and local agencies, and of individuals--preparedness of some who are here.

In case of the massive disaster of an earthquake, and there is no more potentially massive natural disaster in my own country than a great earthquake, there is almost certain to be a spontaneous international reaction. Practically every nation will want to provide some assistance. In the case of the

Peruvian earthquake, for instance, 69 nations provided aid. Under these circumstances, there is a great need for a disaster assistance information clearing house such as we are seeking to establish for NATO.

I am glad to be able to say to this gathering that the document on policy and procedures for disaster assistance for NATO, which plan envisages working for the establishment of a disaster information clearing center, was accepted last Friday by the NATO Council. I do here wish to register my gratitude to our co-pilots of Italy for their assistance in helping us steer this policy action through to acceptance by the NATO Council.

Two years ago, President Nixon urged NATO "to create a committee on the Challenges of Modern Society to explore ways in which the experience and resources of the Western nations could most effectively be marshaled toward improving the quality of life of our peoples." And he meant all peoples. "Our purpose," he said then, "would be to share both ideas and benefits, recognizing that these problems have no national or regional boundaries." His message of welcome to you at the beginning of this meeting reiterated that point.

At our opening session, Dr. DuBridge spoke of the influence we must exert, of the selling we must do. It is teaching--instigating--persuading. It is the example we must set. When we leave here--whoever we are, wherever we go--we must not simply file away in our heads or desks or shelves the facts and analyses gained at this conference.

Man has learned to control the great epidemic diseases--once the scourge of mankind.

Our ultimate goal should be nothing less than man's control of one more natural danger--the earthquake. Certainly the human misery and the waste of resources involved in natural disasters such as earthquakes rightfully transcend whatever differences may exist between the nations of this earth.

It is heartening to all of us to join with this group from many nations in the peaceful use of our collective knowledge against a common threat.

Let us continue actively the relationships established here during the last few days, and share our knowledge and experiences with all interested nations, either in future meetings of this kind or through bilateral contacts.

Let us use this meeting to help stimulate all of our countries--singly and jointly--to go forward with actions dealing with the problem we have been discussing--earthquakes.

LIST OF PARTICIPANTS TO THE MEETING

BOLIVIA

Mr. Rene Rodriguez
Geophysical Institute of Bolivia

CANADA

Dr. S. Cherry
Prof., University of British Columbia
Chairman, Canadian National Committee for Earthquake Engineering

Dr. W. C. Milne
Seismologist, Department of Energy, Mines & Resources

Mr. T. R. Durley
Regional V. P., Manufacturers Mutual Fire Insurance Co.

Mr. W. W. Mathers
Director of Operations, British Columbia Civil Defense

Mr. A. L. Brown
Long Range Planning and Policy Development, Canada Emergency Measures Organization

Mr. D. A. Matheson
City Building Inspector, Vancouver, British Columbia

CHILE

Mr. Hector Burr
Consul General of Chile, San Francisco

CHINA, REPUBLIC OF

Mr. H. C. Pan
Counselor for Science and Technology, Embassy of China
Washington, D. C.

Mr. Ta-Liang Teng
Assoc. Prof. of Geophysics, University of Southern California

DENMARK

Mr. Per W. Prellesvig
Consul General of Denmark, San Francisco

Miss Anna Madden
Danish Consulate General, San Francisco

GERMANY, FEDERAL REPUBLIC OF

Dr. Rolf Schaefer
Interior Ministry

Mr. Werner Obenhaus
Interior Ministry

GREECE

Mr. Antonios Protonotarios
Consul General of Greece, San Francisco

ITALY

Mr. Carlo Calenda
Minister, Ministry of Foreign Affairs (Co-Chairman of Meeting)

Dr. Giuseppe Migliore
Dir. Gen. for Civil Protection, Ministry of Interior

Dr. Vincenzo Aurigemma
Civil Protection, Ministry of Interior

Mr. Mario Della Chiaie
Dir. Gen., Firemen Corps, Ministry of Interior

Dr. Guido Ortolani
Dir. Gen., Special Services, Ministry of Public Works

Mr. Rosario Ferlito
Engineer, Ministry of Public Works

Dr. Giuseppe Colucci
Ministry of Public Works

Mr. Salvatore Pontieri
Military Attache, Italian Embassy, Washington

Dr. F. Peronaci
Professor, National Institute of Geophysics

Mr. Attilio Cipollini
Superior Council of Public Works and Engineering

ITALY (con't.)

Mr. Arrigo Fratelli
Chief Engineer for Public Works, City of Agricento

Dr. Raffaele Mezzacapo
Division of Farmland Improvement, Ministry of Agriculture

MEXICO

Dr. Emilio Rosenblueth
Autonomous University of Mexico

NEW ZEALAND

Dr. Robin Adams
Superintendent of Seismological Observatory

PHILIPPINES

Mrs. Estella Sindico
Under Secretary of Social Welfare

PERU

Col. Humberto Rosas Calderon
Vice President, Council for Reconstruction and Rehabilitation at the May 31st Earthquake Zone

Mr. Leonidas Ocola
National Scientific Investigations Council

PORTUGAL

Mr. Arthur Ravara
Engineer, National Council for Scientific and Technical Research

SPAIN

Mr. Rafael Ferver
Consul General of Spain, San Francisco

TURKEY

Dr. Kazim Ergin
Prof., Geophysics, Istanbul Tech. University (Co-Chairman of Meeting)

TURKEY (con't.)

Dr. Erhan Karaesmen
Assoc. Prof., Construction Engr., Middle East Tech. University

Mr. Alkut Aytun
Head, Earthquake Research Institute, Ministry of Housing and Construction

UNITED STATES OF AMERICA

Hon. Lee A. DuBridge (Chairman of Meeting)
Member, President's Science Advisory Committee

Hon. George A. Lincoln
Director, Office of Emergency Preparedness

Hon. Darrell M. Trent (Co-Chairman of Meeting)
Deputy Director, Office of Emergency Preparedness

Mr. Robert Shea
Vice President, American National Red Cross

Mr. Stephen Tripp
Disaster Relief Coordinator
Agency for International Development

Mr. Herbert R. Temple, Jr.
Emergency Planning Director, State of California

Mr. Donald Lowell
Emergency Planning Director, State of Alaska

Dr. Charles F. Richter
Professor Emeritus of Seismology, California Institute of Technology

Dr. Bruce A. Bolt
Professor of Seismology, University of California, Berkeley

Dr. Daniel Linehan, S. J.
Western Observatory, Boston College

Dr. Peter A. Franken
Professor of Physics, University of Michigan

VENEZUELA

Mr. Andres Fernandez
Engineer, Ministry of Public Works

Mr. Felix Briceno
Engineer, Ministry of Public Works

Mr. Renee Torres Baralt
Exec. Sec./Architect, Fundasocial

Mr. Ramon Ignacio Mendes Gomez
Engineer, Ministry of Public Works

Mr. Jorge Del. Carpio Baker
Engineer, Ministry of Public Works

Mr. Reynaldo da Costa
Fundasocial

UNITED NATIONS

Mr. Bernard Kofsky
Spec. Asst. to Commissioner for Technical Cooperation

NATO

Dr. Gunnar Randers
Assistant Secretary General for Scientific Affairs

EUROPEAN EARTHQUAKE ENGINEERING COMMISSION

Dr. N. N. Ambraseys
Professor, Imperial College, London

EUROPEAN SEISMOLIGICAL COMMISSION

Dr. F. Peronaci
Instituto Nazionale di Geofisica, Rome, Italy

INTERNATIONAL ASSOCIATION OF SEISMOLOGY AND PHYSICS OF THE EARTH'S INTERIOR

Mr. Leonard M. Murphy
Assoc. Director for Seismology, National Oceanic and Atmospheric Administration

INTERNATIONAL RELIEF UNION

Mr. Claudio Bay-Rossi
Deputy Consul General of Italy, San Francisco

INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

Dr. J. P. Eaton
U. S. Geological Survey, Menlo Park, California

SOVEREIGN ORDER OF MALTA

Count Carl Wolfgang Ballestrem
Rome, Italy

Frederic Butler, Brig. General, USA (Retired)
San Francisco, California

PROGRAM PARTICIPANTS

Dr. Jack Oliver
Lamont-Doherty Geological Observatory
Columbia University
Palisades, N.Y. 10964

Dr. Clarence Allen
Professor of Geology and Geophysics
California Institute of Technology

Dr. C. Martin Duke
Professor of Civil Engineering
University of California at Los Angeles

Mr. D. Earl Jones, Jr.
Chief Civil Engineer
Architecture and Engineering Division
Dept. of Housing and Urban Development

Mr. Creath Tooley
Region 8
Office of Emergency Preparedness
Bothell, Washington

Mr. James Tobin
Office of Emergency Preparedness
Washington, D. C.

Dr. E. L. Quarantelli
Director, Disaster Research Center
Columbus, Ohio 43201

Prof. Frederick L. Zimmerman
Council of State Governments
Washington, D. C. 20036

Prof. James M. Brown
Professor of Law
George Washington University
Washington, D. C.

Capt. David Riley
Public Relations Secretary for the Western States
Salvation Army
San Francisco, California 94119

Dr. Theodore H. Levin
Federal Insurance Administration
Dept. of Housing and Urban Development

Mr. H. J. Degenkolb
H. J. Degenkolb Associates
San Francisco, California

Mr. Karl Steinbrugge
Pacific Fire Rating Bureau
San Francisco, California

Mr. E. Jack Schoop
Bay Conservation and Development Commission
San Francisco, California

Mr. George Mader
American Institute of Planners
105 Pecora Way
Menlo Park, California

Miss Evelyn Maley
American Red Cross
San Francisco, California

Mr. Joseph H. FitzGerald
Atlantic Richfield Co.
711 West 8th Avenue
Anchorage, Alaska 99501

Dr. Robert E. Wallace
U.S. Geological Survey
Department of the Interior
Menlo Park, California

Mr. Lloyd Cluff
Woodward-Lundgren and Associates
Oakland, California

Mrs. Lidia Selkregg
American Society of Planning Officials
Federal Field Committee for Development and Planning
Anchorage, Alaska 99501

Dr. J. Eugene Haas
University of Colorado
Boulder, Colorado 80302

Mr. R. J. Williams
Superintendent and General Manager
Department of Building and Safety
Los Angeles City Hall
City of Los Angeles, California

Mr. Gordon C. Larkin, Jr.
Office of Emergency Services
State of California

Mr. Stan Chambers
News Reporter
KTLA
5800 Sunset Blvd.
Los Angeles, California 90028

Mr. Ralph Burns
Director, Region 7
Office of Emergency Preparedness
Santa Rosa, California

Prof. George W. Rogers
University of Alaska
Juneau, Alaska 99801

CONFERENCE PARTICIPANTS

AMERICAN RED CROSS

Mr. Richard Gordon
Special Assistant to the Vice President for Disaster Services
San Francisco, California 94117

Mr. Emil Lewis
Deputy Manager
Western Area Headquarters

Mr. Robert Lucey
Manager for Division and Chapters
Western Area Headquarters

Mr. Sherman March
Assistant Manager for Divisions and Chapters
Disaster Services
Western Area Headquarters

Mr. Jesse V. Haws
Disaster Representative
Western Area Headquarters

PENNSYLVANIA STATE UNIVERSITY

Mr. B. F. Howell, Jr.
Professor of Geophysics
College of Earth and Mineral Sciences
College Park, Pennsylvania 16802

STATE FARM FIRE AND CASUALTY COMPANY

Mr. Maury E. Barnes
3033 Cleveland Avenue
Santa Rosa, California 95401

DAMES & MOORE

Mr. Raymond Fox
1028 Connecticut Avenue, NW
Washington, D. C.

VETERANS ADMINISTRATION

Mr. Richard McConnell
Civil Engineering Service

Dr. Charles Henke
Chairman
Advisory Council

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)

Mr. Rutlage Brazee
Washington, D. C.

Mr. Wilbur Eskite
Washington, D. C.

EARTHQUAKE MECHANISMS LABORATORY, NOAA

Dr. Don Tocher
Director
San Francisco, California

Dr. Robert D. Nason
San Francisco, California

BUREAU OF RECLAMATION/DEPARTMENT OF THE INTERIOR

Mr. Jack B. Lindeman
Sacramento Regional Office

DEPARTMENT OF DEFENSE

William T. Leggett, Jr., LTC, USA
OSD/ISA, Rm. 43870, Department of Defense
The Pentagon

OFFICE OF CIVIL DEFENSE

Mr. John W. McConnell
Assistant Director for Plans and Operations

Mr. George N. Sisson
Director, Shelter Research Division

Mr. W. H. Opperman
OCD Region 7

CORPS OF ENGINEERS

Mr. Richard S. Rahte
Chief, Emergency Operations Branch
Civil Works

Brig. General Frank A. Camm
South Pacific Division Engineer

Mr. Larry Nishihara
Los Angeles District

HEADQUARTERS SIXTH ARMY

Col. Thomas R. Sutton

Col. George D. Styer

LTC Wilmot Hall

Major Micheal Maxwell

Mr. Greene

OFFICE OF THE SURGEON GENERAL/DEPARTMENT OF THE ARMY

Col. Earl H. Power
Office of the Surgeon
Headquarters, 6th Army
San Francisco, California

OFFICE OF NAVAL RESEARCH

Mr. Ben J. Cagle
Pasadena, California

ADVANCED RESEARCH PROJECTS AGENCY

Mr. Jack F. Evernden
Nuclear Monitoring Research Office

HEALTH SERVICES & MENTAL HEALTH ADMINISTRATION
DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

Mr. Matthew Hall
Regional Program Director for Emergency Health Services
DHEW Region IX
San Francisco, California

Mr. Jerry Kosro
Regional Engineer
DHEW Region IX
San Francisco, California

ENGINEERING CONSTRUCTION AGENCY DEPARTMENT OF HEALTH, EDUCATION & WELFARE

Mr. Ross Webb
Structural Consultant

Mr. Vincent Rice

DEPARTMENT OF HEALTH, EDUCATION & WELFARE

Mr. Dean Snyder
Defense Coordinator
Washington, D. C.

STRUCTURAL ENGINEERS ASSOCIATION OF SOUTHERN CALIFORNIA

Mr. Clarkson W. Pinkham, President
Los Angeles, California

Mr. Carl B. Johnson, Past President
Los Angeles, California

AMERICAN INSTITUTE OF PLANNERS

Mr. Louis J. Fourcov
City of Palo Alto, California

Mr. Joseph M. Prochaska
8009 Corteland Drive
Knoxville, Tennessee 37919

CALIFORNIA INSTITUTE OF TECHNOLOGY

Dr. Hardy C. Martel

U.S. GEOLOGICAL SURVEY

Mr. Robert E. Altenhofen
Menlo Park, California

Dr. G. J. Lensen
New Zealand Geological Survey
Menlo Park, California

Mr. Ray Laird
USGS/DHUD Project
Menlo Park, California

ATOMIC ENERGY COMMISSION

Mr. Maido Kari
Chief, Mobilization Branch
Washington, D. C.

DEPARTMENT OF TRANSPORTATION

Mr. Greer A. Busbee
Director for Operational Readiness
Office of Emergency Transportation

Capt. Donby Mathieu
U.S. Coast Guard

Mr. William S. Peterson
Federal Highway Administration

SMALL BUSINESS ADMINISTRATION

Mr. J. R. Sungenis
Asst. Assoc. Administrator for Financial Assistance
Washington, D.C.

NATIONAL BUREAU OF STANDARDS

Dr. H. S. Lew
Washington, D. C.

TELEDYNE GEOTECH

Mr. R. A. Arnett, President
Dallas, Texas

Mr. James E. Fix
Senior Geophysicist

DEPARTMENT OF COMMERCE

Mr. J. Terence McCracken
Director, Office of Emergency Readiness
Washington, D. C.

ECONOMIC DEVELOPMENT ADMINISTRATION/DEPT. OF COMMERCE

Mr. Myrle B. Lane
Western Regional Office
Seattle, Washington 98109

AMERICAN CONGRESS ON SURVEYING & MAPPING

Mr. Jack Church
U.S. Geological Survey
Menlo Park, California

STANFORD RESEARCH INSTITUTE

Dr. James Sinko
Menlo Park, California

NATIONAL LEAGUE OF CITIES

Mr. Stan Scott
Associate Director
Institute for Governmental Studies
University of California, Berkeley

CITY OF ANCHORAGE

LTC Douglas M. Clure
Director, Civil Defense/Disaster Office

MODEL CODE STANDARDIZATION COUNCIL

Mr. Gaylon Claiborne
Building Officials and Code Administrators - International
Chicago, Illinois

Mr. Vincent Bush
Supt. of Buildings
Vernon, California

LAMONT-DOHERTY GEOLOGICAL OBSERVATORY

Mr. James Dorman
Assitant Director
Columbia University
Palisades, New York

UNIVERSITY OF CALIFORNIA (BERKELEY)

Dr. Robert L. Wiegel
Professor of Civil Engineering

Dr. H. Bolton Seed
Professor of Civil Engineering

CITY OF SEATTLE

Mr. George D. Smith
Director, Department of General Services

CONRAD ASSOCIATES

Mr. William E. Gates
Senior Associate
Van Nuys, California 91401

AMERICAN IRON & STEEL INSTITUTE

Mr. Elliot O. Stephenson
Newhall, California

McCLURE & MESSINGER

Mr. Frank E. McClure
Oakland, California

THE WHITE HOUSE

Mr. Harry Blaney
Washington, D. C.

SYSTEMS DEVELOPMENT CORPORATION

Dr. Zivia Wurtele
Santa Monica, California

SMITHSONIAN ASTROPHYSICAL OBSERVATORY

Mr. Charles A. Lundquist
Assistant Director, Science
Cambridge, Massachusetts

DEPARTMENT OF STATE

Mr. Joseph Brown
Acting Inspector General of Foreign Assistance

Mr. Jay Blowers
Office of Environmental Affairs
Washington, D. C.

Mr. Alan D. Berlind
Office of NATO and Atlantic Political/Military Affairs
Washington, D. C.

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

Mr. John M. Gibson, Chief
Management Operations Branch
Washington, D. C.

STATE OF CALIFORNIA/OFFICE OF EMERGENCY SERVICES

Mr. Michael J. Colby

Mr. Frank Rothganger

Mr. Loren D. Fields

NATIONAL SCIENCE FOUNDATION

Dr. Charles C. Thiel
Washington, D. C.

CITY OF SAN FRANCISCO

Mr. Edward R. Joyce
Director, Mayor's Disaster Corps

ENVIRONMENTAL PROTECTION AGENCY

Mr. Curtis M. Everts
San Francisco, California

EARTH ENVIRONMENT MONITORING, INC.

Mr. Renner Hofman
Sacramento, California

FERVER ENGINEERING COMPANY

Mr. Greer W. Ferver
San Diego, California

Mr. John W. Hackbarth
Santa Paula, California

THE SALVATION ARMY

Major William Lane
National Disaster Expert
Las Vegas, Nevada

PACIFIC FIRE RATING BUREAU

Mr. Gene Schader
Los Angeles, California

CONFERENCE OFFICIALS AND STAFF

Chairman	Hon. Lee A. DuBridge
Co-Chairman & Executive Director	Hon. Darrell Trent
Ass't. to the Executive Director	Dr. Robert Kupperman
Co-Chairman	Minister Carlo Calenda
Co-Chairman	Dr. Kazim Ergin
Executive Secretary	Dr. Raymond J. Barrett
Ass't. to Executive Secretary	Mr. Douglas Johnston
Assistant Program Coordinator	Mr. Thomas R. Casey
Working Group I - Secretary	Dr. Felix Ginsberg
Working Group II - Secretary	Mr. Philip McIntire
Working Group III - Secretary	Mr. Irving Goodman
Working Group IV - Secretary	Mr. Frank Muckenhaupt
Administrative Officer	Mr. Lawrence Dunn
Ass't. Administrative Officer	Mr. Robert Olson
General Services Officer	Mr. James F. Beck
Ass't. General Services Officer	Mr. Harvey E. Brown
Ass't. General Services Officer	Mr. Ken Leeper
Protocol Officer	Mr. Andre Marcellin
Public Information Officers	Mr. Carl Gidlund Mr. William Gehron

AGENDA
WORKING GROUP ON EARTHQUAKE DISASTER PREVENTION AND HAZARD REDUCTION
(WORKING GROUP I)

CHAIRMAN: Alkut Aytun -- Turkey (Head, Earthquake Research Institute Ministry of Housing and Construction)

VICE CHAIRMAN: Karl Steinbrugge, University of California, Berkeley

STAFF SECRETARY: Felix E. Ginsberg (OEP)

TOPICS

1. Hazard Evaluation
2. Building Codes and Other Hazard Reduction Techniques
3. Economic and Legislative Aspects of Hazard Reduction Techniques
4. Land Use Planning
5. Disaster Education and Information Programs

LIST OF PARTICIPANTS TO WORKING GROUP I ON EARTHQUAKE DISASTER PREVENTION AND HAZARD REDUCTION

Name	Country
Rene Rodriguez	Bolivia
Hector Burr	Chile
Hardy C. Martel	USA
Frank Rothganger	USA
Anne Garcia	USA
N. Ambraseys	England
S. Cherry	Canada
R. J. Williams	USA
Carl B. Johnson	USA
Clarkson W. Pinkham	USA
Charles C. Thiel	USA
B. F. Howell, Jr.	USA
R. D. Adams	New Zealand
Bill Gates	USA
Vincent R. Rice	USA

Name	Country
Ross Webb	USA
Robert E. Altenhofen	USA
Jack Church	USA
William S. Peterson	USA
Jay H. Blowers	USA
Kazim Ergin	Turkey
Pierre St. Amand	USA
Atticio Cipollini	Italy
Lloyd S. Cluff	USA
Wilbur H. Eskite	USA
Louis J. Founcroy	USA
George G. Mader	USA
E. G. Stephenson	USA
James Dorman	USA
Arthur Ravara	Portugal

Name	Country
Robert E. Wallace	USA
Stanley Scott	USA
Jack F. Evernden	USA
R. A. Arnett	USA
James E. Fix	USA
Don A. Matheson	Canada
W. G. Milne	Canada
C. P. Henke	USA
R. D. McConnell	USA
Greer W. Ferver	USA
Maido Kaqi	USA
Raymond R. Fox	USA
Eugene E. Schader	USA
Vincent R. Bush	USA
Ramon Mendez	Venezuela
Felix Briceno E.	Venezuela

Name	Country
Rev. Daniel Linehan, S. J.	USA
Bill Stockton	USA
Ta-liang Teng	Republic of China
Paul T. Wisswaesser	USA
C. Parker Chiapella	USA
Robert L. Wiegel	USA
H. Bolton Seed	USA
George N. Sisson	USA
C. R. Allen	USA
Ing. R. Ferlito	Italy
Greer A. Bushee	USA
C. E. Fritz	USA
R. J. Brazee	USA
C. Martin Duke	USA
Leonard M. Murphy	USA
William A. Sussmann	USA
Gerald Lensen	New Zealand
Frank E. McClure	USA

Name	Country
C. F. Richter	USA
Theodore H. Levin	USA
Emilio Rosenblueth	Mexico
Gaylon R. Clarborne	USA
H. J. Degenkolb	USA
Alkut Aytun	Turkey
Karl V. Steinbrugge	USA

AGENDA
WORKING GROUP ON EMERGENCY RELIEF ORGANIZATION AND OPERATIONS
(WORKING GROUP II)

1. Statement by Dr. Migliore, work group chairman.
2. Presentation by Dr. Vincenzo Aurigemma.
3. Presentation by Dr. Rolf Schaefer.
4. Discussion of Topics:
    a. determination of emergency relief needs and requirements;
    b. structure of emergency response organizations;
    c. disaster services for victims;
    d. national/local government coordination;
    e. search and rescue;
    f. population evacuation;
    g. coordination of international assistance;
    h. restoration of essential services.
5. Presentation by Mr. Claudio Bay-Rossi.
6. Discussion of Topics.
7. Discussion of Recommendations.
8. Drafting of Work Group Report.

LIST OF PARTICIPANTS TO WORKING GROUP II

Name	Country
Dr. Giuseppe Migliore, Chairman	Italy
Mr. Creath Tooley, Vice Chairman	U.S.A.
Mr. Philip McIntire, Executive Secretary	U.S.A.
Earl H. Power	U.S. A.
James Tobin	U.S.A.
Joseph S. Brown	U.S.A.
H. C. Pan	Republic of China
Bernard W. Kofsky	U.S.A.
John Gibson	U.S.A.
Dr. Schaefer	Germany
Frellesvig/Madden	Denmark
Evelyn Maley	U.S.A.
Estele P. Sindico	Philippines
Rene Torres	Venezuela
Reynaldo Dacosta	Venezuela
Peter Franken	U.S.A.
Jack B. Lindeman	U.S.A.
Donby Mathieu	U.S.A.
Greer A. Busbee	U.S.A.
Major Bill Lane	U.S.A.

Attendance List (Cont'd)

Name	Country
Lt. Col. Tom Leggett	U.S.A.
Myrle B. Lane	U.S.A.
D. Earl Jones, Jr	U.S.A.
Marie Mangonon	Philippines
R. S. Rahte	U.S.A.
Col. Salvatore Pontieri	Italy
D. Clure	U.S.A.
Donald Lowell	U.S.A.
Claudio Bay-Rossi	Italy
R. F. Gordon	U.S.A.
Edward P. Joyce	U.S.A.
Vincenzo Aurigemma	Italy

STATEMENT BY DR. MIGLIORE TO WORKING GROUP II

First of all, I wish to extend a cordial greeting to Mr. Tooley, both to him personally and as the representative of the country which so kindly has invited us here and is now giving us hospitality. I want to thank him not only for the general organization of this conference, but also for this beautiful meeting place that the United States Government has chosen. It is a most appropriate city, San Francisco, which combines the interest deriving from its exceptional beauty with the specific interest related to the subject we are going to discuss.

I also want to extend a friendly greeting to all the delegates attending this Conference who represent so many countries; their participation already witnesses the great interest that this meeting has engendered and ensures the positive outcome of the work we are about to start.

I also want to extend my particular and personal thanks to the organizers of this meeting, for making my task easier by allowing me to speak in my language.

I am really happy to meet again with some of the delegates that I already had the pleasure of meeting in Venice on the occasion of the convention to alleviate the effects of floods, a convention which gave birth to the contacts that we are now continuing within the framework of the study of natural disasters as well as of the actions aimed at preventing them or at reducing their consequences.

At present, the world-wide interest in safeguarding the environment in its relation to man, has found, in the noble initiative of President Nixon an authoritative voice for ever more valid and efficient protection of the environment and of man's life and belongings in a joint effort of solidarity among peoples aiming at preventing - as much as possible - the occurrence of calamities and at promoting quick mutual aid when every effort must be directed at the alleviation of their effects.

It is within this framework that this meeting takes place, a meeting whose various study groups will pursue the exchange of knowledge and views that was fruitfully started in the Venice convention on floods.

And just as then, despite the diversity of flood phenomena occurring in every country, extensively illustrated by the delegates, and also the great variety of situations and organizational prearrangements, we will again find, during the course of this meeting and on the subject we are now considering, a number of common denominators and points of general interest.

These points must now be deepened, in reference particularly to the peculiar situations of earthquakes, following the paths indicated in the work programme of our Group.

The particular subject assigned to us regards "The organization and the operation of aid and assistance to the populations stricken by earthquakes".

These problems are in part related to those discussed in Venice, since the forms of assistance and those in which international solidarity may find expression present common grounds whether it relates to floods or to earthquakes.

I believe that a quick look at each point dealt in the subject at hand will be helpful.

The first point concerns: the identification of the needs to be met and the prearrangement of materiel and equipment to cope with those needs.

The recent Italian experience of the earthquake that hit Western Sicily in January 1968, which affected a considerable number of towns with a population of tens of thousands inhabitants showed us the great variety and the huge size of these requirements.

Nor, as proven at that time, is it feasible to evacuate the stricken because, especially in the case of agricultural populations, tied as they are to their farming, it is difficult to transfer them even on a temporary basis to other centres.

This transfer, in fact, involves human problems, bearing repercussion both on the older generations and on the younger ones, submitting family groups to an additional and very painful trauma.

The problem may therefore arise of having to recreate on-the-spot inhabited nuclei, composed of shacks and tents, supplied with all that is necessary to meet at least the fundamental needs of the individual and collective life for the minimum period of time required to restore their dwellings as well as the main public services in the stricken centres.

The second point concerns the structure of the organization of emergency aid: this structure, as well as the legislative rules regulating it, may considerably differ from country to country owing to the local administrative and constitutional system. We will examine together whether these organizational structures might be oriented towards common or similar criteria so that, when the need arises, they may be integrated and may usefully co-operate.

The third point concerns aid to the victims and I believe that, in this particular matter, we should distinctly study the numerous and delicate problems concerning those who lost their life, and those who were injured, and who must be placed in the best possible situation so that they may receive the quickest and most efficient medical treatment.

The criterion adopted by my country in this connection is to remove, if possible, the injured from the stricken area, and to take them where treatment may be more available and facilities more complete. However, other criteria may be set forth and examined by the delegates.

The succeeding point in our Agenda considers the co-ordination between the action carried out by the Central Government and that of the local authorities: therefore, we shall examine how the action of the State, as a national entity, equipped with greater and more adequate means and facilities than local governments, might be integrated by the latter according to their specific responsibilities and authority.

When the event is a really great calamity, then it is the entire country that is affected and that must show its solidarity by bringing help in a unified and co-ordinated manner. This may concern itself, in particular, to the search and hospitalisation of the injured or, if required, to the evacuation of the population. The succeeding points in our Agenda will deal with this situation and the delegates may direct their attention to it as well as make their contribution of experiences and ideas.

The problem of co-ordination of the efforts of international assistance has been in the past examined by various organizations.

A first concrete agreement was reached in 1958 within the Atlantic Alliance and it has recently been reviewed so that it could be of more immediate and effective use.

The new directions, which have generally obtained the consensus of the interested countries, while recognising the usefulness of direct agreements between the stricken and the assisting countries that would bring immediate results, wish however to assign to the organs of the Alliance the task of exchanging information and co-ordinating the operations so as to avoid shortages or duplications. The intention is, moreover, to give in this manner the possibility to the affected country to obtain the materials and the equipment necessary for the emergency operations from the availability of the member countries of the Atlantic Alliance.

We shall also see if and what other steps may be taken to make this assistance ever more vast and operational.

The last point in our Agenda concerns the temporary restoration of the essential services, a topic involving, in depth, studies of both its technical and organizational aspects and allowing possibilities of useful suggestions.

We shall examine the above topics aiming primarily to collect as many viewpoints as possible and secondly to find the basic points on which to direct our talks in order to arrive at useful and conclusive results.

In this way, our painful and grievous experiences will make it possible to set forth suggestions and orientations apt to reduce, as intended by this conference, the negative consequences of these events for the benefit of our countries and for a more civilised society, a society enlightened by a greater and more effect sense of solidarity.

Priority Actions

1. Those that limit further losses.
2. Those that contribute to national survival.
3. Those that are essential to group survival.
4. Those that are essential for individual survival.
5. Those that minimise secondary losses.
6. Those that restore economic activity.
7. Those that correct individual displacement.

Disaster Response Requirements

1. Mobilisation of relief activities.
2. Determination of immediate emergency needs.
3. Provision of fire fighting equipment.
4. Instruction to the survivors regarding what actions they should take.
5. Provision of food and water.
6. Provision of medical supplies and shelter facilities.

PRESENTATION BY DR. R. SCHAEFER TO WORKING GROUP II

International Meeting on Earthquakes,
20th-25th May, 1971, San Francisco

"Co-ordination of International Assistance Efforts"

1. Basic consideration

Two fields of action:

1.1 Activities of the affected country.

1.2 Activities of countries rendering assistance.

2. Affected country

2.1 Co-ordination of all forms of assistance, namely,

- from own country
- from outside

(assistance by other states, by national and international relief organizations),

is a natural responsibility of the country affected by disaster.

2.2 Preparatory measures are required in order to fulfill this task:

(a) definition of responsibility and powers in respect of disaster control and relief operations;

(b) organizational arrangements;

(c) operational facilities (for example, control centre with telecommunication links).

Ad (a):

no generalised system possible, since constitutional structure varies among states (unitary state/federal state), which also applies to the administrative structure (central/decentralised organization).

Ad (b):

establishment of a disaster control staff appears to be the most appropriate solution.

Ad (c):

Necessary equipment (for communicating information and operational instructions)

- stationary telecommunications system (telephone and radio)

- mobile telecommunications system to link the centre with the units at the scene of damage,

3. Countries rendering assistance

3.1 Three fields of action:

(a) co-ordination of all public and private assistance from the respective country;

(b) harmonisation of the scheme with the affected country;

(c) harmonisation of relief operations with other countries offering assistance.

3.2 The most suitable instrument for co-ordinating the various forms of aid from the country offering assistance is a Disaster Control Staff in which the public agencies and organizations concerned are represented.

3.3 Adequate policies for initiating the necessary co-operation with the affected country would be:

(a) contacts established in accordance with diplomatic usage;

(b) contacts with the co-ordinating body of the country affected.

3.4 Experience has shown that liaison between major assisting countries is an appropriate means of avoiding duplication of effort, on the one hand, and uncovered demands, on the other.

In this connection, the following would appear to be important requirements:

(a) close co-operation of the countries rendering assistance and, as the case may be, also in the disaster-stricken countries;
(b) - as suggested in the NATO Mutual Assistance Programme-close co-operation between national experts (of the "field staff") sent to the disaster area.

STATEMENT BY MR. CLAUDIO BAY ROSSI TO WORK GROUP II

The International Relief Union, located in Geneva, Switzerland, was created by the Geneva Convention of 12th July, 1927, under the aegis of the League of Nations, and had been acknowledged by the United Nations. It comprises eighteen African, American, Asian and European states, both members and non-members of the Organization of the United Nations. Among the Western European nations are Belgium, Finland, France, Italy, the Federal Republic of Germany and Switzerland, and among the Eastern European nations: Albania, Bulgaria and Poland.

The Union therefore has a universal scope. All member nations are committed by the 1927 Convention, in a pact which is so far unique in the universal context. It entails mutual solidarity and relief in the event of a natural disaster.

Since its inception, the Union's major concern has been that of giving solid scientific planning to its activities, by drafting and publishing a series of studies of a high scientific level, as well as an exhaustive collection of notes, recently published. The onset of the Second World War and the simultaneous depletion of its funds forced the Union to resort to the United Nations by applying for assistance to the Organization. This was needed in order to acquire new strength, particularly in view of the ever-increasing cost of scientific publications of its sector. In turn, the United Nations called on UNESCO which, in accordance with its budget commitments and institutional frame of reference, took upon itself the cost of part of these studies. It transferred a sum paid by the Union, and the two Bodies signed an agreement along these lines on 24th December, 1968.

This introductory statement appeared necessary in order to report on an experiment conducted on the scientific bases of international relief and to inform the conference on this work.

Taking all this into consideration, the International Relief Union intends to make as a contribution to the Conference's work some suggestions on the problem that the Union considers fundamental of the international relief. That is to say the problem of its organizing structure within the framework of international collaboration of those countries willing to participate.

This structure, especially in the case of relief in earthquake disasters, must take into consideration the preliminary studies concerning the characteristics of the areas affected by these disasters, as well as of the study of relief instruments more appropriate to be used when disasters strike. However this structure must assure, at the same time, an active intervention organization by fast instruments and appropriate materials for collective efficient relief means, which have a large influence on the above-mentioned studies.

The International Relief Union thinks that a substantive relief action may be identified with this conclusive activity.

Whereas it is logical to consider how far UNESCO, which has undertaken only part of the scientific activity of the Union, will be able to effectively operate on its own by extending its scientific activity within its institutional frame of reference, it is necessary first of all to pose the question of how it will be possible to face scientific foundations and preparation in a field in which new requirements and new research and experiments, as well as a probable geographical broadening of such issues, will demand highly specialised technical equipment and considerable funds.

This is a line of thought which we would like to submit to the conference on behalf of the Union, in view of the Union's specific experience in this sector. It is our opinion that the problem of scientific bases of assistance, seen in an international context, can find a solution by means of a set of specialised national and international bodies, which would avail themselves of the assistance of high-level scientific personalities and pool the results of their studies.

Among the European Institutions which have acquired an international renown, two are located in Italy: one of them being international and the other national. A third is located in Yugoslavia.

On the other hand, with respect to the very relevant issues of the organization of co-ordination of relief and, more particularly, that of emergency operations, the Union holds the following view. That should many states be endowed with considerable funds and effective institutions on their respective national level, their work in the international context would still be subject to co-ordination on strictly pre-ordered executive bases, with an immediate practical effectiveness.

The Union has already expressed its views on this subject in the past, and wishes to state them once more to this meeting. These views envisage the need of creating regional sub-groups within the general network, and in this regional context geographical traits should merge with the geophysical features of the areas under consideration. These sub-groups would be mandatory in view of the setting up of means common to the states comprised within such areas, allowing for quick transfer of assistance and rescue, storage of relief and reconstruction material and - last but not least - constant co-operation among the states in the interest of the implementation and unification of action and methods of national rescue teams called upon to operate in the common area. A joint pool of vehicles and material and, if possible, a joint executive centre should be located in the most appropriate geographical site of each area of the member states.

These guidelines have been submitted to the Secretary General of the United Nations by a certain number of diplomatic missions, among them, Italy, in connection with the anticipated tasks of the Union within the framework of the United Nations.

May it now be allowed to recall, with respect to the complex problem of funds in aid of international assistance, that the Union has already availed itself in the past of the opportunity of representing the conclusions of the "Froelich Plan". This plan, drawn up by the well-known Swiss jurist and economist, is founded on the relationship between the presumed evaluation of disasters assessed by each individual nation, and the financial capacity for intervention on the part of each nation in the occurrence of natural disasters. This in order to establish a contribution based on percentages, in proportion with the financial capacity of each, and which every member nation would commit itself to pay in favour of the disaster-stricken nation. In due course, the Union will give detailed information on the sections of this study deserving major interest and study.

In conclusion, the Union wishes to draw the attention of the group to the following points which are worth bearing in mind as situations evolve:

- the adoption of the Convention of 12th July, 1927, which is still in force, as a parameter for a general agreement on international assistance;
- the setting up, within the framework of a general agreement, of regional sub-groups charged with the co-ordination of men and means for prompt intervention;
- the adoption of an automatic plan for finances, such as the one proposed by Dr. Froelich.

GUIDANCE FOR DEVELOPING NATIONAL EARTHQUAKE PREPAREDNESS PROGRAM.

1. National governments should develop and distribute a comprehensive set of procedures to local officials in seismic areas to prepare them to respond to a severe earthquake. Included would be detailed instructions on ways: to prepare for an earthquake occurrence; to provide immediate medical attention to the victims; to determine if para-earthquake problems exist and methods to alleviate these problems; to ascertain accurate assistance requirements and develop plans for deploying outside assistance when it becomes available; and to restore emergency communications.

2. National governments should plan to centralize emergency assistance efforts as much as possible to facilitate control. It is recommended that mass shelters should have feeding facilities nearby so that people will not have to be transported to a different area. Individuals that require medical attention should be fed and sheltered in a separate facility.

3. National governments should plan to co-locate as many sources of assistance as possible, designed to help victims return to a normal life, in a single area for the convenience of those seeking aid.

4. National governments should designate one organization to have overall authority to direct and coordinate its disaster assistance efforts. Each nation should encourage local governments to designate a counterpart organization to coordinate disaster assistance matters.

5. Nations with the potential for experiencing serious earthquakes should prepare and regularly update earthquake geologic hazard maps for areas of seismic risk.

6. National governments should undertake a substantial preparedness effort in the area of search and rescue. Improved techniques of search and rescue should be developed and scientifically tested to determine the most effective techniques under different circumstances.

7. National and local officials should develop detailed plans for evacuating a large number of people from areas of high earthquake or tsunamis risk. Strong efforts should be made to ensure that residents of these areas are familiar with these procedures.

8. Officials should restore essential services in an earthquake disaster area to reduce the hazard to these systems from future earthquakes as well as facilitate urban and social advancement.

9. National governments should make preparations to conduct post-earthquake studies of emergency operations, including restoration of essential services, in all relevant disciplines after a major temblor. The resulting data should be thoroughly analyzed and disseminated in order to improve future disaster responses. Existing plans and procedures should be modified in view of these findings.

10. National governments should develop a program to recruit, train, and deploy volunteers, in the event of a disaster, in accordance with the specific needs of the country.

AGENDA
WORKING GROUP ON REHABILITATION AND RECOVERY
(WORKING GROUP II)

1. Chairman's Opening Remarks

2. The Alaskan Earthquake: A Case Study

   - Film: "Response to Disaster"

   - "Management of a Recovery Program"
     by Joseph H. FitzGerald

   - "Planning for Earthquake-Prone Areas"
     by Lidia L. Selkregg

   - "Social Process During the Reconstruction Period"
     by J. Eugene Haas

   - "Economic Effects of the Earthquake"
     by George W. Rogers

3. "The Peru Earthquake of May 21, 1970: Ten Months of Recovery and Reconstruction" by Stephen R. Tripp

4. Working Group Discussion of Selected Issues Related to Rehabilitation and Recovery

5. "Restoration and Reconstruction" by Mario Delle Chiaie

6. "Reconstruction Criteria" by Giuseppe Colucci

7. Chairman's Closing Remarks: Discussion of Chairman's Summation Paper

LIST OF PARTICIPANTS TO WORKING GROUP III

Chairman
Mr. Stephen R. Tripp, USA

Vice Chairman
Dr. Guido Ortolani, Italy

Staff Secretary
Mr. Irving B. Goodman, USA

Dr. Giuseppe Colucci, Italy

Mr. Mario Delle Chiaie, Italy

Mr. Joseph H. FitzGerald, USA

Mr. Arrigo Fratelli, Italy

Dr. J. Eugene Haas, USA

Dr. Raffaele Mezzacapo, Italy

Dr. George W. Rogers, USA

Col. Humberto Rosas Calderon, Peru

Dr. Lidia L. Selkregg, USA

CCMS No. 9

AGENDA
WORKING GROUP ON ROLE OF GOVERNMENTS UNIVERSITIES, INDUSTRY AND VOLUNTEER ORGANIZATIONS
(Working Group IV)

Thursday, May 20

3:00 p.m. to 5:00 p.m.	Introductory Remarks, Chairman and Vice Chairman Introduction of Panel Members Discussion of Topic: Identification of Resources
5:00 p.m. to 6:00 p.m.	Discussion of Topic: Human Factors Aspect: Psychological and Sociological Effects of Earthquake Risk, Warning, Actual Seismic Disasters and Post-Disaster Experiences - Part I

Friday, May 21

10:00 a.m. to 11:00 a.m.	Discussion of Topic: Human Factors Aspect - Part II
11:00 a.m. to 1:00 p.m.	Discussion of Topic: Improvement of Perception of Risks and Response to Earthquakes
3:00 p.m. to 5:00 p.m.	Discussion of Topic: Decision Making in Disaster Situations
5:00 p.m. to 6:00 p.m.	Discussion of Findings and Recommendations of Working Group

Saturday, May 22

Preparation of Chairman's Report

LIST OF PARTICIPANTS TO WORKING GROUP IV

Chairman

Dr. E.L. Quarantelli, USA

Vice Chairman

Dr. Erhan Karaesmen, Turkey

Members

Count Carl Wolfgang Ballestrem, Italy

Mr. A.L. Brown, Canada

Professor James M. Brown, USA

Mr. Ralph D. Burns, USA

Mr. Stanley H. Chambers, USA

Mr. Gordon C. Larkin, USA

Dr. Werner Obenhaus, Federal Republic of Germany

Captain David Riley, USA

Professor Frederick L. Zimmermann, USA

Staff Secretary

Mr. Frank J. Muckenhaupt, USA

REPORT OF THE CHAIRMAN TO WORKING GROUP IV

25th May, 1971

The other three Working Groups focused on the problems in disasters. Our Working Group instead looked at the organizations and agencies involved in some way in disasters - the groups that handle the problem. We thus examined the rôle of governments, universities, industry and volunteer organizations in disasters.

Our discussions centred on three topics:

1. the nature and goals of disaster organizations - what they should be and what they should be trying to do;
2. disaster planning and training - what it should be at all time stages - before, during and after a disaster; and
3. disaster study and research - what we know and what we need to know.

As a result of our discussions we came up with 27 specific recommendations. I will not read them since you all have them at this moment in front of you. Instead I will indicate the major themes in each of our three major categories of recommendations.

First, as to disaster organizations and goals, an earthquake - or almost any disaster - obviously involves a physical agent. However, the prevention of or protection from, the response to and recovery from such physical events, are all highly dependent on the nature and quality of the organizations and agencies involved in disaster activities. Put in another way, the need is not just for disaster organizations but organizations of a particular kind and with certain goals. What kind and what goals?

We suggest there is a need for one central agency with contingency funds and personnel with very many skills, fully and solely responsible for co-ordinating disaster responses. It is difficult to find one such agency in most national disaster organizational structures. Clearly implied here also is the notion that it is not meaningful to develop agencies just for certain kinds of disaster agents such as earthquakes.

We also recommend that disaster relevant agencies pay attention in the same way to pre-impact problems as they do to impact and post impact problems. That is, a better balance in focus is needed. Whether governments or mass media, all disaster relevant groups should concern themselves with preventing or protecting against disasters as well as concerning themselves with impact or recovery and rehabilitation problems.

We also noted the need for some kind of organization to gather disaster data, primarily of an informational nature. Others of the working groups reached this conclusion also. Our recommendation is for a new international agency or centre to gather all relevant physical and social data on disaster phenomena and the groups involved in such events.

As to disaster planning and training, our position is as follows. It is not enough to plan. Effective and efficient organizational planning necessitates realistic planning. How can planning be made more realistic?

We suggest that there are some disaster associated problems of more crucial significance than others. Authority lines and specific functions of emergency groups need always to be clearly specified. There is a need to keep up-to-date inventories of vital but easily disrupted support systems. It is absolutely necessary that some specific group have the pre-impact assignment of clear cut operational responsibility for the quick reconnaissance and damage assessment needed after massive and widespread disasters.

Besides making planning more realistic by focusing on critical and significant emergency problems, plans can be made more realistic by the nature of their testing and by the nature of the training given for disaster purposes. Unexercised plans are worse than no plans at all. But such exercise of plans as are carried out, must be done through the involvement of disaster organizations in everyday emergencies. In other words, disaster plans and their testing should not take place segregated from the routines of a society. Disaster plans and their testing must be a part of the routines of citizens and communities.

In this connection, we particularly recommend that knowledge about disasters and reactions to them be made a part of the regular education of children in a society. We advocate not special courses. Instead we suggest that the myths and misinformation many people have about disasters can be lessened by dealing with them as part of the regular educational programme of a society.

Likewise, if planning is to be realistic, it must adequately incorporate volunteer organizations into the overall planning effort. The disaster efforts of volunteer groups are a particularly valuable supplementary source of aid in disasters, at both the national and international levels. But their rôle, as well as the part unorganized volunteers might play in disasters, needs to be very clearly specified in disasters.

Finally, as to disaster study and research, we took the following position: good planning is dependent upon knowledge. The development of such knowledge is in turn dependent upon basic and applied studies. What kind of research is therefore needed?

Our answer is not necessarily more studies. Far more important is that we have better research. Better in what sense? In at least three senses:

1. taking advantage of opportunities,
2. making systematic and continuous balanced studies, and
3. translating existing knowledge into practical applications.

On this basis, we recommend that stand-by teams of social and physical scientists be always ready to study in the field all aspects of massive disasters during and immediately after they occur. While it may appear to be heartless to be engaging in studies during the emergency period of a catastrophe, it is actually quite foolish and self-defeating in the long run not to take advantage of unfortunate events when they do occur. No major disaster should go immediately unstudied - governments should see to it that appropriate funds and persons can be quickly despatched to a disaster site.

Likewise, disaster research if it is to have appropriate pay-off cannot continue to be conducted on a hit or miss basis, almost depending on chance as to what is studied by whom. Long-range programmes of research on the legal, sociological, psychological and socio-economic factors involved in disasters should be launched to complement the research being done in the physical sciences and engineering area. All the knowledge in the world about the physical aspects of disasters or even very good ability to predict them will be of limited value, unless there is the equivalent knowledge of how to socially organize preventive, protective, recovery or rehabilitation efforts. The ultimate goal is always the saving of lives and the alleviation of suffering, not the acquisition of knowledge per se.

In this connection it should be noted that much knowledge about disasters currently exists. It has, however, not been translated into practical applications. Our Working Group strongly recommends that efforts be made to take what is already known and to transform this into concrete steps and actions that will help to prevent and protect against disasters and to help in responding to and recovery from disasters. We know much already; such knowledge should be used. We of course need more knowledge and thus more research, about disasters but what already exists in the social and physical areas should be better mined than it has been.

If we move on some of these recommendations, there will be an improvement in the ability of all societies to prevent - if possible, to respond to - if needed, and to recover from - if necessary, large scale disasters.

I thank the members of Working Group IV. I hope I have not misrepresented their views in writing this final draft of the report.

(Signed) E.L. QUARANTELLI
Chairman
Working Group IV

SOME PROPOSED ISSUES FOR DISCUSSION BY WORKING GROUP IV

1. Reconstruction Goals and Plans

Should the goals of reconstruction be rehabilitation or recovery? What are the problems of developing sound redevelopment plans without adding undue delays to the reconstruction period? To what extent is advanced (predisaster) planning feasible? Often, the rehabilitation that does occur falls short of the dreams engendered in the plans. What factors contribute to this shortfall and can they be overcome?

2. Reconstruction Priorities

Certain essential services automatically receive top priority in a rehabilitation programme. Beyond these, there is the necessity to resolve conflicts between the needs and desires of individuals, on the one hand, and the community as a whole on the other, especially in the distribution of scarce resources and community funds. Can priorities be established to best serve all interests, to maximise the cost-effectiveness of recovery, and to return the community to a "normal" status in the shortest period of time?

3. Legal Considerations

How can the question of property ownership be resolved when significant changes have been wrought in the land configuration of the affected area?

4. Population Outmigration

What are the implications of population outmigration for long-range economic and social recovery of a community? How should this factor be taken into consideration in planning for rehabilitation? To what extent is this problem aggravated as the time increases between the earthquake and reconstruction of (a) housing, (b) services, (c) employment?

5. Industry Outmigration

How serious is the problem of industry shifting to alternative (existing or new) locations rather than restoring damaged facilities in the disaster area? What are the principal factors that might induce an industry to make such an outmigration decision? Is it possible to predict which industries are likely to leave and under what conditions? Should government attempt to influence industry outmigration decisions (either by encouraging them to stay or to leave) and under what conditions?

6. Resettlement

When is resettlement of an entire community feasible and what are the problems encountered?

7. Hazard Reduction Consideration in Rehabilitation Activities

In requiring that post-earthquakes rebuilding incorporate hazard reduction features, what conflicts with economic efficiency criteria may be introduced? How can compliance be insured?

8. Self-Help Projects

What types of self-help projects are feasible following an earthquake? Under what conditions are they appropriate?

9. Earthquake Insurance

What impact does insurance have on rehabilitation and recovery? Should insurance be voluntary or mandatory? What features should be included in an earthquake insurance programme?

10. Studying the Long-Range Effects of Earthquakes

How significant would long-range studies of disasters be in improving our ability to cope with their consequences? What pre-, trans-, and post-disaster data should be collected? How can a standardised international programme be developed that will insure comparability of study methodology.

CONFERENCE DOCUMENTS

Page

German Field Hospital of the Order of Malta in the Earthquake Area of Peru 1
(Report on the activities of the MHD in Peru, 6/10/70-7/27/70).

A Country Paper on Earthquakes in the Philippines. Estella Primicias Sindico, Undersecretary, Operation and Administration, Department of Social Welfare, Manila, Philippines. 2

Studies and Recommendations on Rehabilitation of Services and Installations in Case of Natural Disasters. Col. Humberto Rozas Calderon - Table of contents. 3

Schematic Tables on the Organization of Civil Protection in Italy. Ministry of the Interior, General Management of Civil Protection and of Anti-Fire Services, Rome 1971. 4

History and Type of Earthquakes in Italy during the Last Ten Years. Ministry of the Interior, in collaboration with the Ministry of Public Works and the National Institute of Geophysics. 5

On the Value of Historical Records of Earthquakes. N.N. Ambraseys, Engineering Seismology Section, Imperial College of Science, London SW7 6

Earthquake Resistant Design, NBC 1970. R.H. Ferahian, National Research Council of Canada, Division of Building Research, Ottawa. 7

Earthquake Zoning in Canada. W.G. Milne, Victoria Geophysical Observatory, Victoria, Canada. Abstract. 8

Report on German Relief Operations in Disasters Abroad - 1969/1970 9

A Study of the 28th March, 1970, Earthquake in Gediz, Turkey, with Emphasis on the Behaviour of the Reinforced Concrete and Masonry Structures. Dr. Erhan Karasemen, Chairman of the Civil Engineering Department, Middle East Technical University, Ankara 1971. 10

Page

Experience Gained from Recent Earthquakes in Turkey Alkut Aytun, Assistant General Director, Disaster Research Institute, Ministry of Reconstruction and Resettlement, Turkey. 11

The Rôle of Science in Protecting Man against Earthquake Disaster. Kazim Ergin, Technical University of Istanbul, Turkey. 12

Safety and Survival in an Earthquake. Prepared jointly by the US Department of the Interior/Geological Survey and the Office of Emergency Preparedness. 13

The San Fernando Earthquake of 9th February, 1971. Lessons from a Moderate Earthquake on the Fringe of a Densely Populated Region. 14

Toward Reduction of Losses from Earthquakes, Conclusion from the Great Alaska Earthquake of 1964. National Academy of Sciences, Washington, DC, 1969. Notification of a full report to be published later. 15

Earthquake Hazard Reduction. Executive Office of the President, Office of Science and Technology, Washington DC 1970. 16

Urban Reconstruction Planning: The Alaska Experience. Lidia Selkregg, Planning Officer, Federal Field Committee for Development in Alaska, 19th May, 1971. 17

The National Emergency Committee, The Chinbote y Trujillo Earthquake of 31st May, 1970, Peru. Notification of a report. 18

Seismic Risk Studies in the United States. S.T. Algermisson, Chief, Geophysics Research Group, NOAA. (A synopsis) 19

Some Developments in State and Federal Earthquake Hazard Reduction Programs. Karl V. Steinbrugge, University of California, Berkeley. 20

Types of Construction and Special Building Standards. Eng. Ferlito and Eng. Cipillini. A synthesis. 21

Seismic Maps. Dr. Peronaci. A synthesis. 22

Prevention of Earthquakes - Resulting Disasters and Techniques for Danger Reduction. Dr. Peronaci. A synthesis. 23

Page

Planning and Zoning for Seismic Hazard, Part I - A General Proposal by Jack Schoop, AIP; Part II - A specific Application: Portola Valley, California, by George G. Mader, AIP. 24

Urban Planning and Land Zoning, Lloyd Cluff, Woodward-Lundgren and Associates (abstract). 25

Response to Geologic Hazards of Earthquakes. Robert E. Wallace, National Center for Earthquake Research, US Geological Survey. 26

Building Codes and Special Construction Ordinances. Henry J. Degenkolb, Structural Engineer, San Francisco (abstract). 27

Tsunami Hazard Education: Report of a Pilot Study. J. Eugene Haas. (abstract). 28

Seismic Risk Mapping in the United States. S.T. Algermisson and L.M. Murphy. (abstract) 29

Disaster Prevention and Hazard Reduction. R.J. Williams. 30

*General Information on Organization and Activities for Earthquake Disaster Response in Turkey. Alkut Aytun, Assistant General Director, Disaster Research Institute, Ministry of Reconstruction and Resettlement, Turkey. (Working Paper 6, 14th May, 1971) 31

On the Value of Historical Records of Earthquakes. Reference. 32

La Legislation italienne pour les constructions dans les zones Sismiques. Ing. Ferlito 33

Scenario for the San Fernando, California, Earthquake. US Department of Commerce, National Oceanic and Atmospheric Administration. Summary. 34

Scenario for the Niigata Earthquake. US Department of Commerce, National Oceanic and Atmospheric Administration. Summary. 35

San Fernando, California, Earthquake of 9th February, 1971. US Department of Commerce, National Bureau of Standards Report, March 1971. 36

Schematic Tables on the Organization of Civil Protection in Italy. Reference. 37

Page

Management of a Recovery Program. Joseph H. Fitzgerald. Summary 38

Planning for Earthquake-Prone Areas. Lidia L. Selkregg. Summary 39

Social Process During the Reconstruction Period. J. Eugene Haas. Summary 40

The Alaskan Earthquake Economic Effects. George W. Rogers. Summary 41

The Peru Earthquake of 21st May, 1970: Ten months of Recovery and Reconstruction. Stephen R. Tripp. Summary 42

Restoration and Reconstruction. Mario Delle Chiaie. Summary 43

Reconstruction Criteria. Giuseppe Colucci. Summary 44

Peru Earthquake of 31st May, 1970, Preliminary Report, Earthquake Engineering Research Institute, September 1970. 45

The American Rôle in Disaster Relief, Agency for International Development, Washington DC, August 1970. Notification of a popular pamphlet. 46

The Alaskan Earthquake - A Progress Report - 279 Days of Federal Reconstruction Effort. Office of Emergency Planning, 29th December, 1964. Notification of a popular pamphlet 47

The Great Alaska Earthquake of 1964 - Human Ecology. National Academy of Sciences, Washington DC, 1970. Summary 48

Peru Earthquake, 31st May, 1970. Agency for International Development, Disaster Relief Report Reprint. Index 49

After-Action Report - Alaska Good Friday Earthquake, 27th March, 1964. Prepared by the Alaska District US Army Corps of Engineers, January 1968. 50

*History and Type of Earthquakes in Italy During the Last Ten Years. Reference. 51

Page

Italian Disaster Assistance Regulations Applying to Damages Caused by Earthquakes to Agricultural Entities. Reference. 52

The Alaska Earthquake, 27th March, 1964 - Lesson and Conclusions. Geological Survey Professional Paper 546, 1970. Summary. 53

Retablissement des Services Essentials. Ing. Arrigo Fratelli. 54

Abstract on Modalities and Criteria Used by the Government of Italy for the Permanent Restoration of Property Destroyed by Earthquakes. Dr. Giuseppe Colucci. Reference. 55

Basic Concepts for the Formulation of a National Emergency Law in Italy. 56

Urban Reconstruction Planning: The Alaska Experience. Lidia Selkregg. Reference. 57

The National Emergency Committee, Earthquake of 31st May, 1970. Presentation by Col. Humberto Rusas Calderon. Reference. 58

Rehabilitation of Services and Installations in Case of National Disasters. Col. Humberto Rusas Calderon. 59

German Field - Hospital of the Order of Malta in the Earthquake Area of Peru. Reference. 60

State of California Emergency Plan - Part Three - Compendium of Legislation and References. 61

Group Emergency in Community Crisis: A Study of the Conditions Conducive to the Development of Collective Behavior. Arnold R. Parr. Summary. 62

Disaster Research Center, the Ohio State University, Publications. 63

Operational Problems of Organizations in Disasters. E.L. Quarantelli and Russell R. Dynes, Department of Sociology, Disaster Research Center, the Ohio State University. 64

Interorganizational Relations in Communities Under Stress. Russell R. Dynes and E.L. Quarantelli, Department of Sociology, Disaster Research Center, the Ohio State University. 65

Page

Organization Under Stress. E.L. Quarantelli, Department of Sociology, Disaster Research Center, The Ohio State University. 66

Adequacy and Inadequacy of Disaster Plans and Preparations. Arnold L. Parr, Department of Sociology, Disaster Research Center, the Ohio State University. 67

Some Observations on Organizational Problems in Disasters. E.L. Quarantelli, Department of Sociology, Disaster Research Center, The Ohio State University. 68

* Repeats from miscellaneous.

GERMAN FIELD HOSPITAL OF THE ORDER OF MALTA IN THE EARTHQUAKE AREA OF PERU

Report on the Activities of the MHD in Peru - 10.6 - 27.7.1970

On 31st May of this year Peru was stricken by one of the worst earthquake catastrophies in the history of mankind.

As part of the German aid, the Relief Service of the Order of Malta (MHD) took up activities in the earthquake area. The experience gathered there served to complete the knowledge of medical relief service already acquired by the MHD in Vietnam. For this reason we shall report in the following notes on the relief activities in Peru.

The Extent of the Catastrophe

During the first days following the earthquake even the Peruvian Authorities were completely at sea about the extent of the disaster. It was first assumed that only the coastal area with the towns Trujillo and Chimbote had been badly hit. The first aerial photographs of the Andean valleys however showed that the Huylas Valley, north of Lima in the Sierras between the Cordillera Negra and the Cordillera Blanca with the major towns of Huaray (65,000 inh.), Yungai (19,500 inh.) and Caraz (12,000 inh.), were the worst affected. The town of Yungay with its nearly 20,000 inhabitants, was completely buried under an immense avalanche of rubble, earth, mud and ice. Only a very few inhabitants had been able to save their lives. In Huaraz there were 16,000 people buried under the ruins of the city, destroyed up to 80%. Nearly all the 250,000 inhabitants of the valley were homeless. The extent of destruction was betwen 80 and 100% in nearly all places.

Major relief activities started from all over the world as soon as the full extent of the catastrophe became known. All these reached the scene of the disaster only in the second week after the catastrophe. A few states of the American Continent (Chile, Argentine, Brazil, USA and Cuba) arrived there with their relief teams in the very first days, but the destroyed and blocked up roads leading to the heavily affected Andean region, hindered their efforts at first to a considerable degree. It was not possible at the beginning to organize an aerial supply-service because of a dense blanket of dust that lay over the entire valley area.

The German Aid

As soon as the full extent of the disaster became known in Germany, two industrial enterprises (Hospitalia and Hochtief AG) presented a field hospital complete with 50 beds, surgical and X-ray equipment and independent electric supply to the German

Government for the purpose to be forwarded to the Peruvian Government for use in the earthquake area. The German Federal Government represented by the Ministry of the Interior arranged for the Ambulance Corps of the Order of Malta (MHD) to despatch a medical staff to run the Hospital and the Technical Relief Service (THW) to organize the set up, the technical service and the water supply.

First of all - on 11.6., 13.6. and 2.7. - the field hospital, four water-purification plants, electricity plants, four field kitchens, as well as major supplies of medicine, blankets and tents were sent off by the Archbishopric of Cologne, the Caritas and the MHD. These supplies were flown into Peru by the Federal Air Force. The medical team accompanying these supplies consisted of the doctors Dr.Med. Christoph Biesing (Cologne), Dr.Med. Rainer Junkers (Aachen), Dr.Med. Erich Kröger (Oldenburg)and four ward sisters: Wilma Schmitz (Munich), Martha Dabbelt (Cologne), Maria Müller (Trier) and Mechtild Weber (Paderborn), all belonging to the MHD. All of them had had long experience in Vietnam. Two cooks of the MHD: Wolfgang Volk and Wolfgang v. Birgelen, who were to organize the field kitchens, and twelve employees of the THW completed the team.

The first problem that had to be faced on arriving in= Peru, was the choice of a site for the field hospital. It did not seem advisable to follow the original plan of the Peruvian Government to build up the hospital in Huarez. Thirty-one doctors of all nationalities had by now arrived at the Provincial Hospital of Huarez and were already looking for work. The severely injured persons had been flown out of the earthquake area to Lima or to other towns at the coast or else had died in the first days after the disaster. Medical first aid was therefore no longer needed. Under these circumstances and aspects one could doubt the necessity, a fortnight after the catastrophe, of erecting the field hospital at all.

After consultation with the Peruvian Ministry of Public Health, it appeared desirable to go on with the project in a slightly different form. The character of the field hospital should be changed from a surgical emergency station to a general hospital. The hospital equipment was therefore completed from supplies sent by the Federal Government and the MHD to correspond to this new scheme. Besides this a dispensary was set up in the hospital to enable a normal medical service for the population. The transformation of the field hospital was, as it appeared subsequently, extremely useful also for other reasons. These will be given later in this report.

In agreement with the Peruvian Ministry for Public Health the site of the hospital was chosen in the town of Recuay (6,000 inh.) in the southern part of the Huaylas Valley, which had been 80% destroyed. Even before the disaster there had been an extensive area of new settlements but poorly provided for from the medical aspect. For the entire province (about 500 km^2 and 23,500 inh.) there was only an elderly doctor in this town. It was therefore decided for the hospital to remain there under Peruvian direction and with Peruvian staff to function as a general hospital going beyond its original destination as an emergency station.

The medical care of the population was in operation already three days after the arrival of the hospital in Lima in the Recuay area. This was achieved in spite of difficulties in receiving transportation facilities from Peruvian military trucks, an extremely good performance, especially as a 23 hours convoy drive was necessary to bring the hospital from Lima to the place where it was to be set up.

This very quick start of the hospital's functions - compared to others from countries and organizations - was due especially to the help coming from the Peruvian Embassy of the Order of Malta, the Germans living in Peru and Church Authorities. Next to the members of the German Development Service (DED), who had been working in Peru already before the catastrophe, it was they who gave the best support to the project. Many, normally lengthy, bureaucratic procedures could be shortened thanks to connections with the Cardinal of Peru and Peruvian offices and authorities. The establishment of radio contact between the hospital and the Ministry of Public Health was a most valuable help. Teachers and pupils of the German school in Lima worked in shifts until late at night at the wireless receiving station of the Health Ministry in Lima in order to receive and to transmit the wishes of the hospital. The reinforcement of supplies and all other problems were solved in the quickest and most direct manner.

Work in the Field Hospital of the Order of Malta

The population of the affected areas lived - for fear of renewed earthquakes - in tents, huts and other self-built emergency shelters. Many fell dangerously ill through the freezing night temperatures in these 3,000-4,000 m altitudes. The dispensary of the hospital was therefore crowded every day. Patients who were not acutely ill had to wait often up to three days, as the doctors were unable to see to more than 120 patients each day.

The attached survey in diagnose-groups gives a report on the treatments carried out during six weeks. The range of ailments corresponded somewhat to European conditions. Tropical diseases, or other special ailments, expected by the medical team in this country and known to them from Vietnam did not occur in these Andean altitudes. The population was however badly infested with vermin, especially fleas.

Most patients who came to the dispensary suffered from diseases of the respiratory system, principally angina, infections such as influenza and bronchia catarrhs. Serious pneumonia, especially among small children combined with measles, was also very frequent. Tubercular diseases were relatively frequent, on the whole however less often than for instance at Vietnam. As often as there osteomelitis could be observed in connection with chirurgical illnesses. The population seemed less troubled by worms than in Vietnam with its unhygienic living and feeding conditions.

It was noted that many patients, as a consequence of the earthquake, suffered from continual nervous anxiety, insomnia and waking up from nightmares.

Already after a few days after the hospital had been opened the wards were filled to capacity. The composition of medical cases corresponded to that in German hospitals. As necessity arose a small gynaecological and lying-in ward was later added to the surgical and intern stations.

As to the question of morbidity related to the cases treated, a period of six weeks does not allow any conclusive insight into general health conditions in these Andean areas. Besides that the diagnostic facilities were naturally restricted at our hospital.

Efforts to secure Peruvian staff, after the hospital had ended its work under German supervision, were rather difficult. Though, according to information from local doctors, there are plenty of doctors in Lima and in the major towns on the coast and although some of them are not in a good financial position, it proved difficult to get medical personnel to come to this far off and climatically unpleasant Sierra region. After lengthy and at first unsuccessful negotiations, also on the part of the Peruvain Ministry of Public Health, the hospital was eventually handed over to qualified Peruvian personnel (two doctors, three male nurses and three sisters).

Vaccinations and Distribution of Donations

Beside the hospital work, inoculations were carried through. Immediately after the earthquake the Peruvian Authorities had started vaccination especially against typhoid fever. A typhus epidemic never broke out, but a serious epidemic of measles began among small children. In the process of this disease it often came to complications in form of pneumonia and in certain cases even to encephalitic complications. After the outbreak of the measles epidemic the inoculation programme of the Peruvian Authorities was immediately extended to this disease.

The hospital of the Order of Malta took part in these inoculation programmes. Almost every day a doctor and a nurse set out, mostly on horseback, to vaccinate the population of distant ruined mountain villages against typhus and measles. During their six weeks' activity a total of 11,750 typhus and 1,285 measles inoculations were carried out by the German team of the Order of Malta.

Another essential part of their work consisted in the distribution of material donations, coming from the Federal Government and the German Caritas. A precise plan was worked out and the distribution of tents, inflatable mattresses and blankets was carried out by the technical personnel of the hospital in most cases in combination with the vaccination programme. The equipment was handed over after careful investigation on the spot according to the degree of need of each family. In this way a relatively fair distribution was ensured. Though the Maltese team had a lot of work on their hands, they considered the distribution of equipment as a most important task and saw to it themselves.

These three major tasks put a considerable claim on every member of the Order's team. Fortunately enough the hospital had at its disposal, in addition to the four nurses of the MHD, three nurses of the DED as well as three German nuns from Lima. The unaccustomed altitude (3,500-4,000 m) and the difference in temperature (up to 40 degrees C at noon, about 0 degrees C at night) put a further strain on the personnel. Out of 15 members of the team 10 developed temporary systems of mountain sickness (collapse condition, violent headache, short breath). Two nurses developed regular altitude psychoses with somnolence and cramps. One of them had to be flown immediately back to Lima by helicopter and aircraft and later prematurely back to Germany.

Incomplete Hospital Equipment

Working in a field hospital, donated by industrial enterprises and partly unsuitably equipped, showed up a number of deficiencies. In case of an emergency of predominately surgical nature, as was originally envisaged for Peru, some very serious problems would have cropped up.

The placing of operation theatre and X-ray room in the same tent proved to be impracticable. In the case of surgical emergency these two rooms are most heavily frequented and their being in the same tent would have led to mutual confusion and would have been detrimental to the already difficult asepsis situation.

Even more aggravating than this awkward arrangement of the hospital rooms were the deficiencies in the equipment. Quite inexplicably, there was no laboratory, however small. In an emergency hospital it is absolutely necessary for the care of dangerously ill persons to have a laboratory for blood tests, determination of blood groups, crosstests, urine sediment, etc. So later, when already in Peru, a laboratory-set for the most necessary tests was bought from funds given by Caritas and by the Order of Malta. It would be advisable for such a field hospital to have a separate tent unit with X-ray and laboratory equipment.

Normally also the lack of suture material among the surgical equipment would have presented many problems. Fortunately, however, there was a large amount of such material among the medical supplies given by the Federal Government. Also the amount of X-ray films sent along (3 film sizes with only 25 exposures each) did not suffice for a surgical emergency station. After a few days of routine surgical work they had all been used up and it was subsequently extremely difficult to find the appropriate size plates in the necessary quantity in Lima. There was moreover a noticeable lack of equipment of primary importance, such as urinals, bed-pans, thermometers, racks for pincettes and scissors, fixtures for transfusions, etc. There were only cots with a few blankets in the tents.

What was also missing in the hospital equipment was any kind of medicines. At first there were only the medicines donated by the Federal Republic, and, as a result of individual initiative, those sent by the German Caritas. These supplies consisted however only of certain kinds of medicines and surgical dressings in large amounts. A supply of some medicines could be procured at the airport of Lima from donations from other countries. However this random collection of medical supplies was in no way sufficient for intensive treatment at the hospital. Expensive drugs, necessary for the treatment of seriously sick patients were seldom to be found among these gifts. These necessities had to be ordered - if available at all - from the pharmacological firms in Lima or in some cases even bought at the pharmacists.

The Lesson Learnt from the Emergency Operations

In case of emergency a field hospital must arrive as soon as possible at the site of disaster if it is expected to serve its purpose. The field hospital sent out to Peru came too late to give first aid to the victims. Only the fact, that also in normal times the medical service for the population was inadequate, and due to the earthquake its functioning could no longer be effective, justified the activities of our field hospital. Thanks to the transformation of the field hospital into a general health unit and its subsequent work under Peruvian management, it could then contribute in improving the public health conditions.

Prompter action in a future similar catastrophe could be ensured by the resolute initiative of the German Embassy in the affected country. The Embassy should be able to gather the necessary information concerning the disaster and the need for aid and could transmit these data to Germany, without delay. There should moreover be a complete field hospital set together with doctors that have gathered experience in catastrophes and which would be stored at one of the relief organizations, available on sudden notice. This same organization must be in a position to call together immediately a team of medical and technical personnel experienced in catastrophe activity, as the MHD was able to do in the case of Peru.

The storage of a completely assembled field hospital at any of the relief organizations would also have the advantage that the equipment could be constantly checked for completeness and replenished after use. Eventual deficiencies, like those experienced in Peru, could be avoided from the outset.

The good co-operation between the relief organizations (MHD, THW and DED) in the catastrophe area should encourage Federal departments and the leaders of these organizations to co-ordinate their activities already existing in Germany in view of future missions. It should moreover be taken into account, that in the affected country there may be a number of German private persons, who might be willing and able to help. In Peru the active help of this group of persons also contributed to the final success of the project.

For the good co-operation and support we thank all doctors, the Federal Ministry of the Interior, the Federal Office for the Protection of Civilians, the General Vicariate of the Archdiocese of Cologne, the German Caritas association for its constantly judicious and constructive attitude, all doctors and nurses for their unselfish work and excellent personal behaviour, the members of the THW and of the DED, the two cooks as well as Herr. J. Krauthausen, Headmaster of the German School in Lima and Herr M. Rotmann, engineer in Lima.

Table 1

Disease	Absolute	%
Respiratory tract	709	24
Nervous restlessness, anxiety	562	19
Surgical cases	384	13
Digestive system	355	12
Urogenital system	236	8
Rheumatic diseases	177	6
Cardiac and circulatory	148	5
Sundry	414	13
Treatments out-patients	2,783	100
Treatments ward-patients	202	
Total	2,985	

CCMS No. 9

EARTHQUAKES IN THE PHILLIPINES

Undcrsecretary
Operation and Administration
Department of Social Welfare
ESTELA PRIMICIAS SINDICO
Manila, Philippines

Foreword

The Philippines lies within the Orbit of Fire of volcanic eruptions and a spiderweb of tectonic lines and faults which geologists and seismic experts see as a continuous source of fear lying underneath the ocean floor or earth crusts.

Thus, the Filipino people have an abiding interest in the development of the most accurate, intricate, advanced or adequate information or researches undertaken not only by the instrumentalities of the Republic of the Philippines, particularly the Weather Bureau, but also allied researches from other governments of Southeast Asia and the Far East, the United Nations, the North Atlantic Treaty Organisation members, and most particularly from the United States of America.

The Philippine Seismic Situation

Over the entire Philippine archipelago, earthquake averages of the Philippines at different regions over a 50-year period shown by statistics from the Weather Bureau's Seismological Division indicate that:

16 Earthquakes have occurred in Northern Mindanao, Samar and Leyte

13 Earthquakes in Northern Luzon, Batanes and portion of Central Luzon

8 Earthquakes in Pangasinan, Nueva Ecija, Quezon, Mindoro, Marinduque, Romblon

6 Earthquakes in Sulu-Visayan-Panay, Negros, Sulu and Western Mindanao

4 Earthquakes in the Bicol region, Masbate and Catanduanes

FREQUENCY OF OCCURRENCE OF EARTHQUAKES
(Philippine Region)

1. At least one earthquake with magnitude 8.0 or greater is expected to occur every 11.1 years, based on 70-year average.

2. Every 1.8 years, one earthquake with magnitude range of from 7.0-7.9 will occur, based also from 70-year average.

3. For magnitude range of from 6.0-6.9, two to three earthquakes are likely to occur, based on 40-year average.

4. Eleven to twelve earthquakes per year with magnitude range of 5.0-5.9 are expected, based on 10-year average.

5. Forty to forty-one earthquakes per year with magnitude range of 4.0-4.9 will occur in our region, based on 10-year average.

From the facts above, the Filipino is thereby harrassed by the fearful "shaking motions" that crumble colossal structures, crack open lines of gaping pits along tectonic lines, causing not only loss of lives, destruction on property, eerie waves of doom, etc. including tidal waves called "tsunamis" which is generated because of the effect on vast surfaces of water in the archipelagic structure of the 7,100 islands comprising the Philippines.

A review of Philippine earthquakes indicate that as of the period 1949 to thru 1959, three major earthquakes were registered by the Philippine Seismological Office of the Weather Bureau specifically:

Isabela Province	- 29th December, 1949 which recorded some 70 aftershocks that year, but added some 107 aftershocks the following year, 1950. This major earthquake did not wreck heavy destruction on the community (since the record did not reveal any);
Sorsogon Province	- 2nd July, 1954 killed 13, injured 103, destroyed water mains, belfries and some old buildings.
Lanao Province	- 1st April, 1955 (International dateline time 31st March) caused severe damage to properties, killed 291 persons and injured 713 persons.

A major earthquake that occurred in the Philippines on 2nd August, 1968 was terrifying because it hit the heart of metropolitan Manila with a tectonic line believed to have cracked immediately beneath our famous "Ruby Towers" Apartments and killed over 500 people and the whole building wrecked with other effects felt in Manila. The UNESCO billed this as the Luzon (Philippine) Earthquake, 2nd August, 1968.

VIOLENT EARTHQUAKES THAT HAVE AFFECTED MANILA IN HISTORICAL TIMES

Date	Intensity in Manila	Remarks
1589	VII	Violent
1599 June 21	VIII	Destructive
1601 January 1	IX	Destructive, many persons injured
1601 January 16	VII	Violent
1645 November 30	X	Very destructive, large number of people killed and injured
1645 December 5	VII	Violent
1658 August 20	IX	Destructive, few killed and many injured
1665 December 5	VII	Violent
1677 December 7	IX	Destructive, three killed and many injured
1684 August 24	VII	Violent
1750 March 10	VII	Violent
1767 November 13	VII	Violent
1770 December	VII	Violent
1771 February 2	VIII	Destructive
1796 October	VIII	Destructive
1797 February	VII	Violent
1824 October 26	VIII	Destructive
1828 November 9	VII	Violent
1829 December 17	VII	Violent
1830 January 18	IX	Destructive, several victims
1852 September 16	IX	Destructive
1862 March 4	VII	Violent
1862 June 3	X	Very destructive, 320 killed and many injured
1863 July 13	VIII	Very violent
1869 October 1	VIII	Destructive
1872 December 29	VIII	Very violent
1877 June 2	VII	Violent
1880 July 18	X	Very destructive, 20 victims
1881 August 15	VII	Violent
1885 November 19	VII	Violent
1889 May 26	VIII	Destructive
1901 February 14	VII	Violent
1923 November 1	VII	Violent
1923 November 4	VII	Violent
1937	VII or less	Strong, damaged few buildings
1968 August 2	VII	Destructive, more than 300 persons killed

SEISMOLOGICAL STATIONS UNDER THE PHILIPPINES WEATHER BUREAU

Station	Latitude	Longtitude	Altitude above m.s.l.	Bedrock
1. Diliman Geophysical Observatory, Quezon City	14°40'N	121°05'E	70.4m	Tuff
2. Ambulong Geophysical Station, Batangas	14°05'N	121°03'E	10.5m	Volcanic
3. Gulod Seismic Station Batangas	14°06'N	121°01'E	80.0m	Volcanic
4. Legaspi Weather Station Legaspi City	13°08'N	123°44'E	19.0m	Limestone
5. Cebu Weather Station Cebu City	10°20'N	123°54'E	41.93m	Sedimentary
6. Infanta	14°45'N	121°39'E	5.0	
7. Davao	07°04'N	123°36	19m	

Seismicity related to neighboring areas

Seismic activity in the Philippines is related to the situation of the archipelago on the circum-PACIFIC seismic belt. In order to examine general seismic activity in the Philippine Archipelago, in comparison with neighbouring areas, it is interesting to refer to statistics compiled by Gutenberg and Richter (1954). The following table (Table 3.2) shows the annual number of earthquakes in the regions neighboring the Philippines with respect to three different classes of earthquake magnitude. In the table, a, b and c represent the classification of magnitude used by Gutenberg and Richter:

Class	a	b	c
Magnitude	$7\frac{3}{4} - 8\frac{1}{2}$	7.0 - 7.7	6.0 - 6.9

TABLE 3.2

NUMBERS OF SHOCKS IN VARIOUS REGIONS IN AND AROUND THE PHILIPPINES (AFTER GUTENBERG AND RICHTER)

REGION	Total Numbers				Annual Average				
	Shallow		Intermediate	Deep	Shallow			Intermediate	Deep
	a	b	a and b	a and b	a	b	c	a and b	
Japan-Kamchatka	12	46	16	11	0.28	1.64	12.3	0.57	0.38
S.W. Japan, Kyushu, Taiwan	3	22	5	0	0.07	0.79	3.7	0.14	0.00
Philippine Is.	4	19	4	1	0.10	0.68	5.1	0.14	0.04
Celebes	2	16	4	0	0.05	0.57	2.6	0.12	0.00
Samoa-Fiji	0	11	0	0	0.00	0.04	0.9	0.00	0.00
New Hebrides	2	19	23	0	0.05	0.68	6.6	0.78	0.04
Solomon Is.	6	27	4	1	0.14	0.96	6.0	0.14	0.04
New Guinea	4	15	2	0	0.10	0.54	3.7	0.07	0.00
Palau-Guam	1	4	0	0	0.02	0.14	0.6	0.00	0.00
Marianas	1	5	8	2	0.02	0.18	2.3	0.27	0.07

From this table (Table 3.2) it can be seen clearly that the seismic activity in the Philippine Islands is fairly high. We observe that statistically a class "a" earthquake can be expected, on the average, once in ten years in an area around the Philippine Islands, and that about five earthquakes of magnitude about 6 to 6.9 will take place every year somewhere in the Philippine Archipelago.

Seismological Observation

"It should be emphasized that data and other information from seismological observations are the basic and fundamental requirement not only for engineering purposes but also for seismological research".

Evidently, Philippine seismological research is not adequate. Hence, the urgency of increasing observations, technical information,well-equipped observatory stations for the most up-to-date seismological data around the country, including those available from other seismological stations around the world.

UNESCO proposals after the August 2, 1968 earthquake in Luzon (Manila) Philippines called for five new stations in addition to the present network so that local seismicity can be recorded and transmitted quickly for the information of all concerned.

Philippine governmental agencies now coordinating on seismological observations are the Weather Bureau, the Manila Observatory, and the Commission on Volcanology for the most accurate and successful interpretation of day-to-day seismological observations. These agencies tie-up with the neighbor-country seismological institutions especially the Unites States, Japan, or those of the United Nations in collating every information affecting earthquakes, including warning systems on "tsunamis" Great Waves generated by the tremors.

In this context, the Philippine delegate (this writer Undersecretary Estela Primicias Sindico) is attending this San Francisco Conference of Earthquake Experts (1971). However, we shall participate most particularly in the areas of "open and comprehensive exchange of information ... on earthquake problems and the practical measures for mitigating the social and economic effects of major earthquakes" as well as "to produce recommendations to governments with respect to mitigation of earthquake hazards and development of preparedness programs for post-earthquake rehabilitation and recovery" viewed primarily from the Social Welfare aspects.

In this connection, the Philippine Republic has existing agencies and/or instrumentalities mobilized and/or operating under the Office of the President of the Philippines among which are: The Civil Defense Administration, The National Disaster Coordinating Center with the Armed Forces of the Philippines, and other government agencies interlocked and coordinated to implement the Plan on Natural Disasters and Calamities including earthquakes. Executive Order No. 151 of 1970 which created the National Committee on Disaster Operation provided for "a more adequate and effective coordination with disaster operations caused by earthquakes, seismic waves (tsunamis), volcanic eruptions, floods, fires, typhoons, epidemics, major accidents, and similar calamities.

The Standard Operating Procedures of the National Committee on Disasters directs the following primary responsibilities thru the Department of Social Welfare.

1. Undertake on the spot survey of disaster areas to determine the extent of damage and number of victims eligible for relief and assistance;
2. Distribute relief goods and supplies to disaster victims;
3. Provide emergency shelter;

4. Extend guidance, counseling and other special services to boost the morale of the victims;

5. Prepare case record of victims in coordination with participating team and agencies to determine the need and eligibility of disaster victims for rehabilitative services such as cash aids, building materials, additional relief supplies, etc.;

6. Make available the different social services/programs of the welfare department to disaster victims for help;

7. Receive donations for public and private sources.

The specific task above is primarily placed on the Department of Social Welfare (of which agency this writer is Undersecretary for Operation and Administration). It coordinates with the other responsible agencies involved in this massive nationwide task to support and/or assist disaster victims even as they give their respective support to our own welfare programs or services.

The organization of the government agencies proceeds to the local areas and reaches down to the lower echelons in the provincial, municipal and barrio levels. The Department's branches in the rural areas are pivotal in mobilizing instrumentalities for disaster operations. The Department of Social Welfare has recently reached out further by sending out a SET OF SURVEY QUESTIONNAIRE on "DISASTER PREPAREDNESS AND RELIEF PROGRAM" to all governors and mayors all over the Philippines. This questionnaire serves them as "enlightening guide to the organization and implementation of Natural Disasters/Calamities Plan" oriented primarily to disaster preparations and relief programs. The Department of Social Welfare has been meticulously extensively amplifying disaster preparedness against earthquakes or the "mitigation of earthquake hazards and to post-earthquake rehabilitation and recovery" relief programs.

Meanwhile, all the government agencies are mobilized in disseminating informative literature and observations affecting earthquakes and other disasters. Printed matter such as "Safety Tips in Case of Earthquakes," "Earthquake Observations," "Tsunamis", and charts, graphs, and other materials are provided the public for their protection and/or information of the population.

DEFENSA CONTRA DESASTRES

ESTUDIOS Y RECOMMENDACIONES TECNICAS DE REHABILITACION DE SERVICIOS E INSTALACIONES CASO DE DESASTRES NACIONALES

Crl Ing EP Humberto Rozas Calderon

(31 de Mayo de 1970)

CONTENIDO

PROLOGO ....

PRIMERA PARTE

"RECOMMENDACIONES PARA LA DEFENSA CONTRA "DESASTRES"

Pág.

- Estudio de Seguridad de una área contra siniestros de Magnitud 1
- BASES para el planeamiento de NORMAS para la defensa contra desastres (catástrofes) 7
- Medidas técnicas preventivas en la zona de desastres 19
- Planeamiento para la rehabilitación de Servicios - Generalidades 20
- Descripción y características de las diferentes fuentes y cuencas más importantes de las Regionales del Perú 30
- Reconocimiento y Reparación de danõs, en edificios e instalaciones - Organización del trabajo 40
- Bibliografía 41

SEGUNDA PARTE

- Generalidades ....
- Estudio de los Riesgos de Carácter Natural en la Zona Regional 1
- Fundamentos de Alivio de Desastres 4
- Responsabilidad asignada a la FA 9
- Planeamiento de alivio de Desastres 13

- Recuperación de un Desastre 18
- Recuperación de Servicios Públicos esenciales 25
- Efectos de los Desastres Sísmicos 28
- Observación de los efectos de los Terremotos 32
- ENCUESTA, Observaciones geológicas de los efectos de los Sismos ....
- RECONOCIMIENTO y Reparación de Daños causados en Edificios e Instalaciones: Iniciación y Organización del trabajo ....

Le texte complet du rapport peut-être obtenu à
The complete document may be obtained from

Asociacion de ingenieros civiles del Peru,
Filial del cuzco,
Av. Sol 596,
Apartado 388,
Cuzco, Perú.

MINISTRY OF THE INTERIOR

General Management of Civil Protection
and of Anti-Fire Services

* * *

ORGANIZATION OF CIVIL PROTECTION IN ITALY
(Rome 1971)

The Interministerial Committee on Civil Protection is entrusted with the task of furthering studies and setting forth proposals as to preventive measures aimed at avoiding calamities or limiting the resulting damages, handling the coordination between the various emergency plans, the studies for the setting up of government interventions, the collection and circulation of information falling within the requirements of civil protection.

The Interministerial Technical Commission cooperates with the above Committee on all the technical aspects which, under all aspects, fall within the framework of civil protection.

The major executive tasks of the entire system fall within the competence of the Ministry of the Interior - General Management of Civil Protection and Anti-Fire Services.

The Regional Committees on Civil Protection handle, region by region the arrangement of measures aimed at preventing or delimiting the danger of the occurence of every predictable calamity as well as programs relative to the concrete contribution which has to be offered, in case of calamity, by the Region and Local Bodies.

The Government's Commissioner in the Region handles the execution of provisions laid down by the Ministry of the Interior with a view to the organization and arrangement of civil protection services within the regional district. To this end, he resorts to:

- the Regional Office of Civil Protection, whose director is member by right, and secretary, of the Regional Committee on Civil Protection;

The Prefectures - peripheral organs of the Ministry of the Interior - are those ordinary organs of civil protection having the responsibility of seeing to arrangements and plans, province by province, in keeping with ministerial directives as well as, in the case of non-grave calamities, to the coordination, on a provincial level, of aid operations.

The Regional or Inter-regional Inspectorates of the National Firemen Corps, consisting of Provincial Headquarters and detachments, are each directed by a General Inspector whose tasks are as follows: to coordinate the activities of provincial headquarters as regards anti-fire and civil protection services; to command the mobile air squadron set up within the Inspectorate, by handling its organization, training and utilization; to carry out the general inspective functions attributed to it, as well as the control of the activity of anti-fire prevention services effected by provincial headquarters to ensure an uniformity of application and interpretative approach; to take upon itself, in the case of public calamity the responsibility of resorting also to the use of the other mobile aid squadrons or of their units if called upon to work within the regional framework of their competence, and of any other corps division; to supervise, from the technical side, the utilization of forces which take part, as a help, in aid operations.

The setting up of the Zone Mobile squads was determined by the need to be able to resort, in case of calamity, to specially-equipped for emergency interventions. Each unit consists of a Command Section, each having a jeep, an equipped-truck, two boats and a rubber boat; a Special Vehicle Section made up of ground movement equipment (bulldozers, loaders, and truck with dump body), nautical units (amphibian units, boats and barges, photoelectric units, ambulances, etc.) a Logistical Service Section consisting of motor vehicles with barracks material, tents, electric and cooking equipment.

The motor vehicles making up the Zone Mobile squads are stationed at the Provincial Firemen Commands, which, in case of the Unit mobilization, provide the personnel required.

The Central Column stationed in Rome, contrary to Zone Columns which are intended for a "specific purpose" in that - as we have seen - the men making up such "squads" normally carry out their services at the Provincial Fire Stations, has its own set up also as regards personnel.

The dislocation of amphibian vehicles takes into account the hydrogeological characteristics of the national territory. Said special units are, obviously, more numerous in areas where the probability of their utilization is statistically greater.

The Operative Outlay of Mobile Columns provides the framework, in relation to the calamity, of logical priorities in the succession of interventions of the various civil protection units.

The Central Nucleus of Manoeuvres is that unit which is resorted to when aid operations also require the intervention of a large number of men.

The Unit, equipped with autonomous transportation and utilization means, is made up of young men in service at the Anti-Fire and Civil Protection School Centres, attending training courses as conscripted Auxiliary Firemen.

The Center of Coordination is the outcome of the latest experiences which are proved that aid and assistance operations need to be followed and coordinated, rather than by the Center, by a post in immediate contact with the problems that arise from time to time and with a full and direct understanding of the various local requirements.

The Center consists of a set of facilities suitable for ensuring its logicals autonomy and the fulfilment of its tasks, its staff being made up by representatives for Administrations and local bodies involved in the operations.

The Mobile Center of Aid Coordination is equipped with motor vehicles and equipment.

The help of helicopters in civil protection operations is essential. The 16 aircraft at the disposal of the Civil Protection are found in different stations all over Italy.

Experiences of past years have proved the absolute need for an efficient radio network at the service of Civil Protection. The National Firemen Corps has recently made such network more powerful.

The Divisions of Public Aid of the Public Security, besides effecting the normal institutional services, concur, thanks to the special equipment at their disposal, in the initial aid service to populations hit by calamities by handling, in particular, the setting up of relief posts, the pitching of tents and transportation of wounded persons, etc.

The Divisions of Public Aid of the "Carabinieri" carry out similar tasks to those of the Public Security Divisions. Divisions of Public Aid of the National Firemen Corps are now being set up.

The Centers of Prompt Intervention have been set up by the Ministry of the Interior - General Management of Public Assistance - to obtain a more thorough and broad population assistance.

Each Center has been given material supplies that can be used on the spot or transported, with promptness in calamity-hit areas.

The International Aids Administration, in case of grave calamities, participates in the assistance activity by providing food, which is immediately available at the Emergency Centers set up for this purpose and through the use of their social assistance services which envisage the setting up, in hit areas, of assistance centers for children, women and old people.

Auxiliary Units for Civil Protection. The Ministry of Interior has long since tackled the problem of giving shape to the cooperation offered, on the occasion of grave calamity interventions, by boy and girl scout organizations.

The use of young "auxiliaries" on the occasion of the Florence, Biella and Genoa floods or the Sicilian and Tuscany earthquakes have proved the importance of being able to resort to such forces as well as need for increasing and furthering the training of the said forces.

From 1964 to 1969, civil protection drills have been carried out with the following themes and aims:

1964 - ALBAA I: breaking of a dam and, consequently, the need for a prompt concentration of forces in the areas concerned.

1965 - BOREA II: grave natural calamity at a height of over 100 metres - control of the structural efficiency of the Zone Mobile squads.

1966 - CASTORE III: exceptional thunder storm caused fires, collapses and different destructions in various localities.

1967 - DELFINO IV: widespread sinking movements over a mountainous area of roughly 5,000 hectares - checking of training concerning via-sea transportation of barge of facilities and material.

1968 - EOLO V: sizeable inundations.

1969 - FEBO VI: telluric event in the Garganic zone - testing of the Mobile Center of Aid Coordination.

The Sectors of Technical-Scientific Activities cooperate with the Civil Protection Services with studies and surveys aimed at attesting the causes of the phenomena and proposing the proper means to predict or delimit their consequences.

The accelerometric stations stationed at the various Civil Engineering or Municipal stations represent a realization of the Ministry of Public Works which envisages the setting up of a close network of seismic phenomena surveys.

The Provincial Civil Protection Plans have been worked out on the basis of the hypothesis of possible accidents with various approaches which are gradually brought up to date in the light of later experiences.

The National Civil Protection Plan integrates and completes the Provincial plans by handling the coordination among the said plans.

All bodies working on the organization of aids are directed by the General Management of Civil Protection, thus enabling a uniform action of direction and coordination.

History and types of Earthquakes in Italy over the last ten years

SUMMARY

Information is given on the most salient characteristics of the seismicity of Italian soil, with reference to the comparison of the scales of measurement. A short history of the most catastrophic earthquakes registered in the past is also furnished.

The most important seismic events which took place in Italy over the past decade (earthquakes in Irpinia, Sannio and in Western Sicily, the bradyseismic phenomenon in Pozzuoli and the quake in Mignano Montelungo, the earthquake in Roman Tuscia) are described, together with a panorama of essential data for configurating calamities in their various aspects (geophysical, geological and destruction).

For more exhaustively dealing with the subject, information is given on the attempts to forecast seismic phenomena and on the construction for seismic zones.

The action carried out by the Italian Government after the quakes is described, and the experience gained is illustrated.

1. INTRODUCTION

The subject of earthquake hazard reduction, wich is the issue to be discussed in this Symposium, is far ranging, and it includes the economic and financial fields as well as the safeguarding of life and property.

Though its seismicity is less noteworthy than that of other areas in the world, Italy is particularly interested in this subject. Its population density is high, and, especially in the small centres and in the agricoltural areas many buildings dating from ancient times, often built with irrational criteria, are still inhabited. Therefore the effects of the seismic phenomena prove to be quite serious. Moreover, in order to speed up its economic development, the industrial development programme provides for the creation of important plants in Southern Italy, though these are the areas where the greatest number of seismic districts exist.

The present documentation is essentially a brief report on the history and types of the most important earthquakes which took place in Italy during the past ten years, as well as on some other subjects of general interest which appear on the Agenda of the Symposium.

This work is subdivided into three parts: the first part contains information concerning earthquakes, which are briefly described. It is preceded by some indications on seismicity in Italy, and by a short history of the most disastrous events of the past. The second part deals with the subject of precautionary measures against the effects of earthquakes. After a brief examination of the studies regarding the physical forecasting of quakes, the criteria followed in Italy with regards to construction standards for the seismic areas are briefly explained. The third part, while describing the action of the National Government contains a brief description of the actions by the Ministries of Interior, and of Public Works.

The reports also briefly outlines the experience acquired in this field.

The bibliography, at the end of the report, contains an enumeration of the documents closely relevant to the subjects dealt with, and the specific or general studies that are the sources of much of the information contained in this report.

The photographic documentation enclosed shows some aspects of the inhabited centres damaged by earthquakes.

However, within the limited amount of time, at our disposal, many questions cannot be sufficiently dealt with, and others cannot be raised. We therefore cannot thoroughly probe the subjects, but only provide information of some interest for more general discussions.

2. SEISMICITY IN ITALY AND MEASUREMENT SCALES OF EARTHQUAKES

As we know, earthquakes are generally divided into tectonic, plutonic, and volcanic according to whether the waves are of a structural character, derive from phenomena occurring deep within the earth, or are due to volcanic activity. If we put aside the cause and the deepness, and refer only to the so-called secondary aspects (wave propagation, damages) there is no difference among the three types of earthquakes.

Italy is a region of noteworthy seismicity, though it cannot be compared with that of other parts of the world. It is in the seismic zone of the earth, that is to say, in the so-called Alpine-Himalayan circle or of the midlands (the European, the Asiatic, and the American ones), where the greatest number of earthquakes throughout the world originate, and precisely in the geosyncline extending from the strait of Gibraltar to Burma and Turkestan. Moreover, there exist in Italy many volcanoes in various degrees of activity or quiescence.

Amongst those in an active phase are: Etna, which is the most important active volcano in Europe, Stromboli, in a state of continuous eruption, and Vesuvius which is certainly the most famous because of the beauty of the surrounding landscape, and its eruptions which-throughout history — have repeatedly devastated its populated slopes. Not far from Vesuvius, but geologically independent from it, is the area of the Campi Flegrei, which contains a group of volcanoes in various degrees of activity. Many of them are extinct from ancient times, and their craters are now lakes; Solfatara is in a characteristic stage of semi-activity, while Monte Nuovo emerged during the span of one night in 1538, and presently is extinct. Later on, we shall mention this subject, which is connected with seismic activity and with the persistent phenomenon of bradyseism.

The studies carried out during the last few years on the physical nature of the seismic phenomena at their focus, have led to their schematization in two types: earthquakes caused by shearings, and earthquakes caused by an upheaval or a subsidence of the land.

Regarding Italian territory and the seas surrounding it, it has been ascertained that the first type characterizes earthquakes which occur in the Alps and in the lower Tyrrhenian sea, while all the earthquakes in the Appennine region have had as a consequence an upheaval of strata. Moreover, subsidences have been ascertained in the Adriatic which can be linked — according to some experts — to the negative bradyseism of the whole area which was considerable in the past, especially in Istria and in Dalmatia.

In the opinion of these experts the upheavals in the Appennines and the subsidences in the Adriatic sea must be correlated: indeed, the lateral compressions originated by one of the two phenomena might be the cause of the second.

As to the Alps there is the assumption of the existence of a single deep fracture, covered with alluvial material of the Po plain, running from Lake Garda to the Brenta area and further North.

In the lower Tyrrhenian area a system of geological shearings also constitutes the major cause of the local high seismicity. In fact in little more than a century, many earthquakes of considerable intensity occurred in the Calabrian region with epicentres which were never more than 50-55 kilometres from the main fracture line existing in that region.

To these tectonic origin earthquakes must be added those of areas characterized by an active volcanism (generally of minor intensity) and the earthquake in the Lodigiano area of 1951 originated by a strata subsidence at a depth of about 5 kilometres (it must be pointed out that the area is considered moderately seismic).

Earthquakes affecting Italy, generally have low focal depths (the focal depths of volcanic earthquakes seldom exceed one kilometre, while the depths for tectonic quakes are around ten kilometres); though it is not rare to record earthquakes with focal dephts ranging from 20 to 40 kilometres, which take place mostly in the Alpine and Calabrian areas, and in the upper part of the Adriatic, but wich lately have also been recorded in Irpinia and in Sicily.

Italian earthquakes, therefore, fall within the category of normal ones, that is to say, with inter-crustal foci; only some intermediate quakes, having a focal depth ranging from 85 to 400 kilometres, have affected the lower Tyrrehenian area. Therefore, because of the low focal depths those earthquakes which at their epicentre develop a relatively modest energy, cause, on the surface, considerable damage, especially if the structures and buildings affected are old or in bad repair.

Moreover, since the geological structure of Italy is quite variable, also over areas relatively limited, the macroseismic effects of earthquakes — linked as they are to the characteristics of the superficial strata, to those of the land, and to the focal depht — lack homogeneity.

A study of documents concerning Italian earthquakes shows that over the course of time nearly all the regions of the peninsula have been affected with more or less damage, and that seismic activity is irregular.

For some areas the phenomenon is real exception, for others, on the contrary, it occurs with a certain frequency; also the intensity of the shocks varies considerably.

Studies carried out on the topographic position of seismologically unstable areas show, in synthesis, that in Italy the major seismic area follows the direction of the Appennines on the Tyrrhenian side.

The seismic areas of maximum intensity in the peninsula are: the Aspromonte slope towards the Tyrrhenian sea, between the Gulf of Gioia and the Capo dell'Armi; the areas of the Lucanian and Neapolitan Appennines; the Matese mountains; areas of the Appennines in Abruzzo and the Gargano; some wide and fractional areas of the central regions (particularly the Tuscan and Emilian Appennines), parts of the Maritime

Alps, and of the Bresciane, Bellunesi, and Carniche pre-Alps. In insular Italy the seismic areas include some zones in Sicily such as the Gibellina, Peloritan and Iblei hills, the Etna area, and the whole of the Aeolian archipelago.

Some parts of the Po plain (though in the past serious earthquakes have occurred there), the terra d'Otranto, the interior of Sardinia, and some interior parts of Sicily are considered to be non-seismic areas.

For a synoptical topographic picture of the seismically unstable areas and their spatial distribution, Mr. Baratta compiled a map for quakes up to 1934, using almost exclusively historical criterion, for which information concerning damage were available. The map outlines the areas having a seismicity ranging from very slight to catastrophic.

Another map concerning the seismicity of Italian territory was drawn up by the National Institute of Geophisics for the years from 1900 to 1964. This map indicates the maximum degree of intensity registered in various area during seismic disturbances, and it is limited to those earthquakes whose intensity exceeded the VI degree on the Mercalli scale (earthquakes of a lesser intensity have no bearing on problems concerning construction standards for seismic areas).

The above mentioned map should be considered a revision of Baratta's seismic map, since a study limited to a period of 60 years cannot provide definite information on the maximum possible intensity.

The map's scale of 1:1,000,000 (Baratta's was 1:1,250,000) permits a direct comparison with the geological map of Italy.

As regards intensity, degrees have not been directly assigned, but the nomenclature adopted by Baratta has been maintained, also for comparison purposes. Thus each region has been seismically designated as: catastrophic, very intense, intense, medium, light, very light, according to the effects of the various earthquakes.

The National Committee for Atomic Energy has also recently worked out a seismic map concerning earthquakes which occurred between 1893 and 1965. This map ,with a scale of 1:1,000.000 has been drawn from isoseismal lines of the VI degree and higher, regarding 534 principal shocks which occurred during the afore mentioned period. From a study of these maps we may conclude that almost all the Italian peninsula is seismic, and that a fourth or more of its territory may be classified as highly seismic.

It is also interesting to study the frequency and the size of earthquakes in Italy.

Recent statistical research has shown that during the period from 1893 to 1965, excluding the years 1944-45-46, 577 earthquakes occurred with an intensity higher than the VI degree, without taking into account warning shocks and after shocks. It was also ascertained that no earthquakes occurred of the XII degree, and that every 35 years there occurred an earthquake of XI degree, and every 17 years one of X degree. The annual frequency regarding shocks of a degree higher than the VI has been, of 8.24; higher than the VII, of 3.10; higher than the VIII, of 0.95;

higher than te IX, of 0.41; higher than the X, of 0.05, and higher than the XI, of 0.02.

For the above mentioned data we have adopted the Mercalli Sieberg scale, which is generally used in Italy. It is an empirical scale which conventionally indicates the intensity of the shocks causing shaking of the soil, in reference to the effects on the population and on the buildings of the affected areas. It establishes twelve degrees which range from shocks recorded instrumentally to catastrophic ones, with intermediate degrees of a constantly increasing intensity. In estimating the intensity of the shocks from their effects, the entirety of damages and destruction is taken into account.

As to the correspondence of this scale to the scale based on the degree of acceleration imparted by the earthquake to the elementary particles of the earth, that is to say the maximum velocity which the latter acquire from the seismic impulse, expressed in millimetres per second, we wish to point out that up to a few years ago the first and the eleventh degrees of Mercalli scale corresponded respectively to 0-2.5 mm per sec^{-2} and 2,500-5,000 mm per sec^{-2}.

Presently it is pointless to consider dangerous acceleration if it is not also connected with the period (earthquakes spectrum).

We also wish to recall that, besides being expressed by the Mercalli scale and by the degree of accelerations, the manifestation of earthquakes, is also expressed by the magnitude obtained from an analysis of the seismograms.

In Italy, the intensity at the epicentre, according to the Mercalli Sieberg scale, and the magnitude are correlated by means of special formulas for focal depths of less than 20 kilometres. These formulas have coefficients which differ from those used in California where the modified Mercalli scale is used.

In order to facilitate a comparison, the following table lists the intensity at the epicentre, and the degree of the magnitude, both for Italy and for California.

A comparison shows that there is an equivalence only for the lowest degrees; the differences as regards the higher degrees are due to the different types of buildings in the two countries.

Intensity	Magnitude	
	Italy	California
II	2,369	2,333
III	2,850	3,000
IV	3,331	3,666
V	3,812	4,333
VI	4,293	5,000
VII	4,775	5,666
VIII	5,341	6,333
IX	5,955	7,000
X	6,617	7,666
XI	7,327	8,333
XII	8,085	9,000

3. SHORT SEISMIC CHRONOLOGICAL HISTORY OF ITALY

Before describing the earthquakes which have occurred in Italy over the past decade, for which registered scientific data are available, it would be appropriate to recall the most disastrous events which took place in the past, in order to complete an outline of the seismic nature of the soil, on the basis of past experiences.

What has been published regarding seismic phenomena in Italy constitutes a vast bibliography. It includes particular investigations on earthquakes, concise or monographic studies on the topographic distribution of seismic disturbances in certain regions, as well as historical research on the great earthquakes of the past, and collections of data for a history of earthquakes.

Some of the above mentioned documents have drawn the attention of seismologists all over the world. As for example, Professor Mario Baratta's (1868-1935) "Italy's Earthquakes", which contains a documented chronological history of Italian earthquakes from the beginning of the Christian Era, and dedicated to his teacher Professor Giuseppe Mercalli (1850-1914). (From this work we have drawn a great part of the information contained herein).

Italy's physical history, as Baratta stated, "can be considered a long series of calamities, which the unconquered forces of nature slowly prepare, over the course of periods when nature is apparently calm, and which subsequently explode in all their fearful might causing tragic events which men must fatally endure".

This statement refers to the calamities that have occurred throughout history. Amongst such calamities a particularly important one, from the historical point of view, is the earthquake which occurred in Pompei and other centres of Campania in the year 63 A.D.

Besides being the first earthquake which is reported in classical texts (Tacitus - Seneca), it is still possible today to find direct proof — through excavations — of the damage which the city underwent, and of the repairs being done at the time when, in 79 A.D., the city itself was buried under the catastrophic eruption of the Vesuvius.

Throughout the centuries we find reports of numerous catastrophic earthquakes. Without going too far in the past, amongst the most calamitous were: the 1693 earthquake in Eastern Sicily, which destroyed 44 inhabited centres including cities and villages, and which caused the death of about 57,000 people around Catania and Syracuse; the 1783 earthquake which levelled 109 inhabited centres of Calabria and caused the death of about 30,000 people. There were numerous shocks (140 during 24 hours); the most disastrous ones affected above all Reggio Messina, and Scilla where part of a mountain, falling into the sea, caused the death of all those who had fled the areas already affected by the earthquake.

In 1873 several inhabited centres of central and Northern Italy were affected, and amongst them Belluno, two thirds of which was transformed into a mountain of rubble.

In 1883 Casamicciola, a thermal resort on the island of Ischia, already affected in 1881, underwent an extremely violent earthquake of volcanic origin, in which 2,313 people perished and 80% of the buildings were destroyed.

In this century, in 1908 a seismic catastrophe hit Messina and its surroundings — in Sicily — causing the death of about 65,000 people; n Calabria, the city of Reggio was destroyed, and 25,000 inhabitants of hat province perished. The high number of victims recorded was due to the fact that the two principal cities, Reggio and Messina, were in he area of maximum intensity, and as a consequence in just thirty seconds all the buildings were absolutely levelled to the ground. The telluric shock was followed by a seaquake wave which, on the coastal area, made worse the balance sheet of desolation and destruction.

The destruction was of such magnitude that a Committee for the study of the phenomenon was established. This Committee, headed by Mr. Panetti, an engineer, prepared a report which has been used for the ormulation of all subsequent earthquake-resistant standards which we shall mention in this report.

It was on the basis of this tragedy that Senator Giovanni Ciraolo, in considering the event as "the tragic dawn of a great hope", appealed or the establishment of an Organization of Mutual Aid Amongst States for assistance to populations hit by calamities which are beyond the apacity of national energies and remedies. His appeal was echoed in he League of Nations (Geneva), which in 1927 constituted an International Relief Union. A review bearing the same name was published, nd it has repeatedly dealt with seismic phenomena affecting Italy.

In 1915, in the Abruzzi, the villages included within the basin of ancient lake Fucino, which constituted the epicentral area of the phenomenon, were almost completely destroyed. The catastrophe affected also other regions extending to eight provinces with a total surface of 16,000 quare kilometres, causing more than 30,000 victims. In Avezzano, only 5% of the population saved itself; in the epicentral area the victims onstituted 75% of the population.

In the following years other violent earthquakes were registered in different parts of Italy, but the most disastrous was that of July 1930. ast area in Campania, Basilicata and Puglia were affected, and in particular the areas of Irpinia and Vulture. The victims were 1,425, the injured were more than 7,000 and the damaged or destroyed buildings were about 40,000. There were, moreover, a great number of shocks or almost one year: some of them reached the VI degree on the Meralli scale.

From 1930 to 1961 there were no earthquakes as severe as the ones mentioned above, though quakes of a sufficiently high intensity occurred, which caused serious static displacements or the collapse of buildings.

In brief, the chronological history of seismic calamities shows that, from the beginning of the Christian era to today, an estimated 350 earthquakes, ranging from ruinous to catastrophic, have occurred in Italy, and that, from the 15th Century, there have been 177 ruinous earthquakes, of which 88 in the 18th Century and 89 in the 19th Century, of different frequency according to the regions.

4. EARTHQUAKES IN ITALY DURING THE PAST DECADE

During the past decade Italian territory has been affected by several telluric movements. The greater part of them have been of slight importance and some have been recorded only by seismographs.

Nevertheless, there have been violent seismic phenomena: though some — because of the position of the epicentre with regard to the inhabited centres, and of the geological and morphological constitution of the land — have not had serious consequences, others however, caused a total of 272 victims, and wide-spread destruction.

We refer to the earthquake of August 1962 in the Region of Campania, which affected several inhabited centres, and to the more calamitous one of January 1968 which levelled to the ground a number of villages in Western Sicily.

Campania is undergoing the damaging consequences of two phenomena: bradyseism in Pozzuoli in the Campi Flegrei area, and a seismic crisis in Mignano Montelungo in the upper part of the province of Caserta.

In February 1971, Roman Tuscia — and particularly Tuscania — was affected by telluric movements, causing loss of life and destruction.

Our report concerns the above mentioned events and we shall give, for each event, a comprehensive outline including the necessary information regarding the damages of the inhabited centres, and the main characteristics of the areas concerned.

For a synthetical evaluation, we include the following table regarding the main seismological data of the above mentioned earthquakes.

Earthquake	Magnitude principal shock	Time interval between the first shock and the principal one (hours)	Number of warning shocks	Lower limit of magnitude of warning shocks
Irpinia (1962)	6.18	2.4	3	4.5
Sicily (1968)	6	13	7	3
Mignano Montelungo (1970)	4	—	—	—
Tuscania (1971)	4.46	—	—	—

THE EARTHQUAKE IN IRPINIA AND IN SANNIO

a) *Location and essential characteristics of the earthquake.*

In 1962, Irpinia was once again affected by a series of seismic phenomena which, beginning on August 21st and continuing for several days, constituted a seismic period that can be considered as among the most intense that have ever occurred in the area.

The macroseismic area included several provinces (Avellino, Benevento, Salerno, Naples, Caserta, Potenza, Foggia, Chieti, Campobasso) and, in particular, in the area of maximum intensity (IX degree), some Communes in the province of Avellino and of Benevento. (In Naples — at 75 kilometres from the epicentrum — a shock of V degree was registered, and in Rome one of III degree).

The epicentre of the earthquake was located in the boundary-line area between the two provinces of Avellino and Benevento, violently affecting a strip of territory about 50 kilometres long and 20 kilometres wide, between Colle Sannita on the North, and Mirabella Eclano on the South, as can be seen on the map enclosed herein.

This is a particularly interesting area from the seismic and tectonic point of view. It is formed by a group of heights, bordered by lowlands and fluvial valleys, on the whole prevalently irregular with broad calcareous blocks surrounded by clay deposits.

The epicentrum, as we shall later specify, was located in a shearing area at a medium depth of about 40 kilometres, which was greater than any recorded for earthquake in the central and Northern Appenines.

The following table lists the major shocks which were recorded, along with the determination of their magnitude and relative energy. (From a study by D. Di Filippo and F. Peronacci of 1963).

Day	Hour of registration in Rome	Magnitude	Energy (erg.)
21-8	$15^h56^m22^s$	4,52	$7{,}05 \cdot 10^{18}$
»	18 08 24	4,38	$3{,}56 \cdot 10^{18}$
»	18 09 43 ,5	5,86	$5{,}38 \cdot 10^{21}$
»	18 20 05 ,5	6,18	$2{,}61 \cdot 10^{22}$
»	18 45 29	4,49	$9{,}33 \cdot 10^{18}$
»	20 08 57	4,05	$7{,}03 \cdot 10^{17}$
»	21 28 35 ,5	3,94	$4{,}00 \cdot 10^{17}$
»	23 36 37 ,5	3,56	$6{,}21 \cdot 10^{16}$
»	23 40 57	3,46	$3{,}88 \cdot 10^{16}$
22-8	02 05 25 ,5	3,36	$2{,}27 \cdot 10^{16}$

The seismic period, therefore, began with the 3.56 p.m. shock of August 21st, 1962, which had a magnitude of 4.52 and was directly recorded by the stations in Naples, Aquila, Taranto, and Rome; its focal depth was calculated at about 35 kilometres.

Another considerable shock occurred at about 6.10 p.m. with a magnitude of 5.86 and a calculated focal depht of about 49 kilometres.

The most intense shock of the whole seismic period occurred at 6.19 p.m. of the same day, having a magnitude of 6.18 and a focal depth of about 40 kilometres. The village of Ariano Irpino is located in the epicentral area of this shock.

The season, the manifestations of the phenomena, the hour in which the principal shock occurred, and the fact that the inhabitants of the area — knowing from ancient times the dangers of earthquakes — went outdoors after the warning shocks, contributed to limiting the number of victims. (In Molinara, in the province of Benevento, there was only fatality caused by the collapse of buildings; the reports of the following days attributed 16 other casualties to panic, to injuries, and other causes).

In the past the Irpinia and Sannio areas were affected by intense telluric phenomena; in fact, in Baratta's seismic map they are indicated as areas of catastrophic seismicity. Ariano Irpino — for example — the biggest centre amongst those affected by the above mentioned earthquake, was semi-destroyed in 990; in 1180, because of a very intense earthquake, it was for the greater part engulfed by a chasm; in 1456, 600 to 2,200 people died and the village was completely destroyed; in 1694, the greater part of the buildings and part of the Cathedral collapsed, and 8 people died; in 1702 only 20 houses remained undamaged; in 1732 there occurred another great shock; in 1794, the village was damaged; in 1805 and 1905 shocks of maximum intensity took place; in 1930 a disastrous earthquake caused 83 deaths, and 12% of the houses collapsed and 31% were damaged; in 1933 a strong shock occurred.

Throughout the centuries, the other minor centres of the area were also more or less affected by the same calamities.

b) *Description of the effects of the earthquake on the inhabited centres and on building works.*

According to Government reports, following the 1962 earthquake, about 450 municipalities were damaged, 355 of which in Campania, subdivided as follows: 118 in the province of Avellino; 81 in the province of Caserta; 68 in the province of Naples and 53 in the province of Salerno.

Since almost all the villages affected by the earthquake are located on the top of hilly areas, the effects produced by the earthquake could have been influenced by the oscillation typical of the hills themselves. Several inhabited centres were also affected by landslides and by a broad subsidence of the terrain.

The villages in the province of Avellino where the greatest damage occurred were: Ariano Irpino (30,000 inhabitants), Casalbore (3,000 inhabitants), Melito Irpino (3,000 inhabitants), Monte Calvo Irpino (6,000 inhabitants), S. Arcangelo Trimonte (10,000 inhabitants).

Damage to property in the above mentioned villages was respectively of 45%, 50%, 50%, 35% and 60%.

In the province of Benevento the centres which were most affected were: Apice (7,000 inhabitants), Ginestra degli Schiavoni (1,000 inhabitants), Molinara (2,500 inhabitants), Reino (2,000 inhabitants), and San Giorgio La Molara (6,000 inhabitants) with percentages of rooms relatively or seriously damaged of respectively 35%, 50%, 70%, 70% and 40%.

The damaged buildings included churches and above all old bell towers.

As regards railroad tunnels no important damage was coused to the deep ones. Nor were the "Pugliese" and "Campano" acqueduct tunnels damaged. Only the water distribution networks were affected by damage to the street water pipes, caused by the collapse of buildings.

Damage to roads was slight and limited to the retaining walls, bridges, and viaducts.

c) *Evaluation of the intensity of the earthquake on the basis of its destructive effects, and the factors which aggravated its consequences.*

An evaluation of the intensity of the earthquake — carried out on the basis of the data concerning the damages to building works — led to the conclusion that, in the villages most affected by the shock of 6.19 p.m. of August 21st, 1962, such as Reino, Pietralcina, Molinara, Monte Calvo, and Ariano Irpino, the maximum seismic intensity was between the VIII and the IX degree on the Mercalli Sieberg scale.

The effects of the earthquake were greater in the villages of Apice, Pietralcina, and Sant'Arcangelo Trimonte, above all because of the sliding movements which affected the sides of the surrounding hills.

Other factors which heightened damages to buildings were the high degree of looseness and of acclivity — almost to the equilibrium limit — of the terrain on which the majority of the buildings were built.

The houses which collapsed because of the earthquake were few compared to those which were so greatly damaged as to require their demolition. Many partial collapses of attics, roofs, and staircases occurred, especially inside the buildings, so that the first general impression was that the earthquake had caused slight damages. The most damaged buildings were the older ones, of medium height, with two or three floors, characterized by deficiencies in their foundations and in their construction, and further weakened by subsequent modification.

In fact, the foundations rohere not very deep, were based on the superficial strata, and rested on heterogeneous soil. The structures were for the most part of the thrust type, that is to say, constituted by heavy arches or vaults and by roofs without tie rods. These buildings were also characterized by an irregular distribution of the voids and of the solids, and by masonry made of pebbles and roughly squared tuffaceous or calcareous stones, bound together by inferior quality pozzuolanalime mortars and with rubble filling in their internal part. It was noticed that wood was largely used both for the flat attics, and for the roofs.

Subsequent modifications and additions to the buildings, as well as the summary repairs carried out especially after previous earthquakes are factors that contributed towards an increase of the earthquake damage. It was also noted that, in spite of the repairs, after each previous earthquake the mortar and the joints remained disconnected, thus reducing the strength of the buildings.

The earthquake, therefore, caused serious damages to old buildings, already damaged by previous earthquakes, and lacking any earthquake-resistant standards; while other buildings of reinforced concrete frames or built according to antiseismic criteria suffered very little or no damage.

THE EARTHQUAKE IN WESTERN SICILY

a) *Location and essential characteristics of the earthquake.*

In 1968 a seismic phenomenon, with epicentres in the Belice valley, affected a broad area of Western Sicily in the provinces of Trapani and of Agrigento, as can be seen in the geographical map. (The map also shows the location of the operating detachments of firemen, of which we shall speak in paragraph 8).

The Northern area of the Belice valley includes the inhabited centres of S. Ninfa, Gibellina, Salaparuta, and Poggioreale. The first village is located on the Castelvetrano-Alcamo road, while the other three villages, not far from one another, are linked by a road which is a diversion of the above mentioned road. These centres are located halfway up a hill on very steep slopes, having transversal roads with high slopes partially integrated by stairs.

The southern part of the valley includes the villages of Partano, Montevago, and S. Margherita Belice: the first is located on a hill, the second on a plateau, and the third on sloping land. These villages were the most affected by the eartquake, and four of them — Gibellina, Salaparuta, Poggioreale, and Montevago — were completely destroyed.

Other villages, farther from the epicentres, were partially damaged, and in particular Castelvetrano, Salemi, Vita, Alcamo, and Menfi. Buildings were also damaged on the island of Favignana (Egadi archipelago) in Villafranca Sicula and in Ribera.

The Belice valley is considered, by the Baratta seismic map as a non-seismic area, except for a small part near Corleone.

The non-seismicity of the territoy is based on the fact that until 1934 the area was never affected by seismic movements within the epicentral areas, and only slightly by earthquakes outside the epicentral area.

The Belice valley probably felt some shocks radiating from the areas of Corleone and Sciacca, though without notable consequences.

As far as is known, the only seismic movement within the epicentral area in the Belice valley was that of May 11th, 1956, with the epicentre in the proximity of S. Margherita Belice and with a maximum intensity of the V degree on the Mercalli scale.

The territory is generally composed of mesozoic nuclei emerging from an overburden of clay and limestone of the Paleozoic era. The superficial geology of the Belice valley is constituted of sandy clay in a discontinuous stratigraphic series with detrital caloareous and gypsum strata.

The area is crossed by many faults, and the greater part of the inhabited centres is located just in their proximity.

The earthquake was of considerable entity, and characterized by many after shocks. Between January 14th and June 1st, there were 154 recorded shocks higher than the III degree on the modified Mercalli scale. The enclosed table lists the shocks together with the time, the magnitude, and the intensity at the epicentre according to the modified Mercalli scale. (The recordings were carried out by the Institute of Geophysics of Messina University).

The seismic period began on Janaury 14th at about 1.28 p.m., with a shock of 4.6 magnitude, and with an epicentral intensity of 6.6, according to the modified Mercalli scale.

This shock caused considerable damage to buildings in Montevago, Gibellina, Salaparuta, and Poggioreale and lesser damage to buildings in S. Margherita Belice, Menfi, Roccamena, and Camporeale. It was strongly felt in Castellammare del Golfo and in Castelvetrano (V degree); mediumly felt in Agrigento, Palermo, Sciacca, and Alcamo (IV degree), and slightly felt in Salemi (III degree).

The most violent shocks of the whole seismic period occurred during the ensuing three days; the strongest occurred on January 15th at about 3.1 a.m., with a magnitude of 5.9 and an intensity, in the epicentral area, corresponding to the 8.9 degree on the modified Mercalli scale.

The shock almost completely destroyed the villages of Montevago, Salaparuta, and Gibellina, and caused the total or partial collapse of buildings in S. Margherita Belice, Partanna, S. Ninfa, Menfi, Poggioreale, Salemi, and Vita. It also caused damages in the cities of Agrigento, Trapani, and Palermo, as well as in many Communes of the corresponding provinces.

The effects of the quake in the epicentral area were considerable; landslides and a deep depression about 6 kilometres long occurred on the Alcamo-Castelvetrano State Road, between the 11th km. and Gibellina.

The shocks, after the one of January 16 which occurred at about 5.43 p.m., with a magnitude of 5.8 and an epicentral intensity of 8.7, decreased in intensity and in number until the 25th of the same month, when at about 10.57 a.m. a shock with a magnitude of 5.58 and an epicentral intensity of 8.4 was recorded.

Having calculated the epicentrums corresponding to the different shocks, the conclusion was that they did not originate from one focus, but from various foci which progressively became active affecting a broad epicentral area which included the Belice valley.

As to the focal depth it seems (on the basis of the elaborations of the International Centres for the Gathering of Seismic Data) that this was a superficial phenomenon having a depth of between 2 to 33 kilometres.

In the succession of shocks the most destructive ones were preceeded by others of a minor intensity, thus preventing a greater loss of lives.

The shock recorded 10 days after the first calamitous event was unexpectedly violent, and caused new victims this time amongst the relief workers.

b) *Description of the effects of the earthquake on the inhabited centres.*

After the first shocks, 80% of the buildings in Gibellina, a small town of about 6,200 inhabitants in a hilly area, had partially or totally collapsed, while the stability of the remaining 20% was precarious.

The population was completely evacuated after the shocks which preceeded the calamitous one of Janaury 15th.

Persons were found alive under the rubble even four days after the disaster, and 110 dead were extracted.

The shock on January 25 completely destroyed the town.

The villages of Salaparuta and Poggioreale are about 3 kilometres from one another. The first, of about 3,000 inhabitants, is situated on a hill, with narrow steep roads. The shocks of January 14th had already caused serious damage to the buildings, and as result all the inhabitants had already evacuated the village except for a few who were afterwards found under the rubble, when the very violent shocks of January 15th occurred. The last shocks completely levelled to the ground Salaparuta with the exception of only the frameworks of a few buildings which however were seriously damaged.

In Poggioreale, which was less seriously damaged, the telluric shock caused damages and partial collapses, affecting about 50% of the buildings. This village, of 2,500 inhabitants, is also placed on a hilly area and is situated half-way up a hill. The lower part was much more damaged clearly because of the different nature of the ground and of the type of buildings in the area.

The second telluric shock of January 25th caused only minor damages in Salaparuta, however, in Poggioreale all the buildings either collapsed or were uninhabitable, and 28 bodies were found in the two villages.

The buildings of S. Ninfa, a Commune of about 6,000 inhabitants, situated on a hill between Castelvetrano and Gibellina, had the same characteristics as those in the centres described above. The earthquake of January 15th had caused damages consisting of lesions and partial collapse to about 50% of the buildings.

The shock of January 25 worsened the situation, and the number of uninhabitable buildings rose to 95%.

Partanna, one of the most populated centres of the Belice valley (more than 13,000 inhabitants), is also situated on a hilly area on the road between S. Ninfa and S. Margherita Belice. The first shocks of January 14th did not cause considerable damages. However, the strong shock of the following day caused damages to the buildings, making 15% of them uninhabitable.

The new quake of January 25th considerably made worse the situation in the entire village, and the percentage of uninhabitable buildings rose to 40%, it also spread panic amongst the population who completely abandoned the village.

The small town of Montevago, of 3,000 inhabitants, was situated on a plateau South of the Belice valley. Its centre was located on a level area, and the earthquake of the morning of January 15th levelled the village and to the ground caused 85 dead.

S. Margherita Belice is 4,800 kilometres from Montevago, on the road towards Agrigento, and had 7,811 inhabitants. It is placed in a hilly area with slight slopes. The telluric movement of January 15th had caused serious damages and the partial collapse of the buildings and the almost total collapse of the churches. 70% of the houses were uninhabitable after the shock of January 25th.

c) *Evaluation of the intensity of the earthquake on the basis of its destructive effects, and factors which aggravated its consequences.*

In the inhabited centres of Gibellina, Poggioreale, Salaparuta, and Montevago, which were almost completely destroyed, the main shock of the seismic period — calculated on the basis of magnitude degrees — had an epicentral intensity of IX degree on the modified Mercalli scale. However, because of the type of buildings and their age, damage had the global effect of being equal to damage caused by a single shock of at least the X degree on the modified Mercalli scale.

Arranged in a decreasing order of damage S. Ninfa, Partanna, Salemi, S. Margherita Belice, Menfi, and Contessa Entellina were also affected. The damages were comparable to those which could have been caused by a single shock of between the IX and X degree on the above mentioned scale.

For a more precise indication as to the extent of the surface affected by the quake and its intensity the elements of reference used were its effects on the buildings, by comparing the damages of the whole seismic period with those which a hypothetical shock of a determined degree on the Mercalli scale might have caused.

By limiting the calculations to the VI degree isoseismal line, it was ascertained that 140 square kilometres suffered damages equivalent to those caused by a single shock of at least X degree; 720 square kilometres, to those of a shock of IX degree; 640 square kilometres, to those of a shock of VII degree; 3,250 square kilometres, to those of a shock of VI degree.

The telluric movements of the Belice valley had destructive effects because the number of buildings constructed according to the proper safety standards was rather limited. All the buildings in the areas, having on the average two or three storegs above the ground, were characterized by inadequate masonry works, by the existence of thrusting roofs, by the lack of proper connections between the different structural parts, and by roughly built foundations.

The buildings were erected without considering the geology of the subsoil, and the geotechnical condition of the terrain.

The buildings, with the exception of a few having a reinforced concrete load bearing basic structure, were built with local tuffaceous rock masonry, having little resistance, with squared or non squared joints, with mortar made of fine sand and clay, of sand and lime, of inferior quality mortars or cement mortar.

This type of masonry offered a minimum resistance to the horizontal slip stress, and this was also due to the defective bound of the mortar with the tuff.

The horizontal structures were constituted of wooden floors or of masonry vaults of the above mentioned type, and the roofs, which were generally thrusting roofs, were built with wooden rafters resting on the outside main walls and on the main inside walls, without chords.

In the areas of maximum seismic intensity the buildings of reinforced concrete load bearing structure did not collapse, though in some cases they suffered serious damages. In particular, it as noted that in S. Margherita Belice two reinforced concrete buildings of 6 and 7 floors, in an advanced stage of construction, did not suffer notable damages in their load bearing structures, and that only the packing walls and the partitions showed signs of damage.

Also bridge and viaduct structures of small and medium load capacity — either of the arch or of truss type — which were well designed and built with solid foundation, and strongly anchored at the wings, validly resisted the seismic shock.

It should be pointed out that reinforced concrete buildings and the other constructions mentioned above were not designed according to earthquake-resistant standards, since the most seriously damaged areas were not included in the areas listed by the law, which we shall mention subsequently.

THE BRADYSEISMIC PHENOMENON OF POZZUOLI

The Campi Flegrei is a typical example of the alternating of soil upheaval and subsidence in areas of volcanic origin.

Before describing the phenomenon of Febraury 1970, and examining in general terms some theories on the genesis of bradyseism of the Campi Flegrei, we should mention the movements and the eruptions which throughout the centuries have affected the area of Pozzuoli and Cumae.

The ruins of the ancient temple of Jupiter Serapis (Giove Serapide) in Pozzuoli, near the harbour were utilized as a measurement index for the phenomenon. In fact, all the immersions and emersions of the Serapeum are marked by the holes made by mollusks on the columns of the temple. According to historical sources, the temple — which modern archeology believes was a market with annexed thermae — was built (in the 2nd century A.D.) at a distance of about 100 metres from the sea; today it is about 30 metres from the sea.

From the 2nd century A.D. to the 11th century A.D. the Serapeum underwent a progressive subsidence of about 12 metres, from 6 metres above the sea level to 6 metres under sea level.

An inversion of the movement started at that time, and lasted until 1538. The ascending bradyseism occurred together with numerous seismic shocks and with two volcanic eruptions; the one of Solfatara in 1198, and the eruption of 1538 which, during the night between September 28th and 29th, resulted in the formation of the Monte Nuovo (140 metres high and a diametre of 1,250 metres at its base) under which the village and the thermal baths of Tripergola — on lake Lucrino, in the area which is now called Arco Felice — were buried.

As a consequence of the eruption of the Monte Nuovo, there occurred a sudden upheaval of the Serapeum of about 6 metres.

From 1538 to 1945 a progressive subsidence of between 13 to 18 millimetres per year, was recorded. From 1945 to 1951 the land rose 38 centimetres; from 1951 to 1968 it sunk 20 centimetres.

The records for February 6, 1970 show an uplifting of about 80 centimetres compared with that of October, 1968. The lack of intermediate measurements has prevented knowing the precise date when the inversion of the movement occurred, and other data concerning the variations. Because of the rapidity of the movement, the phenomenon had a development similar to the one preceeding the catastrophic event of 1538.

The rising movement continued until May, 1970 with a daily medium growth of about 1.7 - 2 millimetres, in the area of maximum intensity, and with an increase in volume calculated at about 1,500-2,000 cubic metres per day, over the entire surface affected by the phenomenon.

During the period from February 24th to March 10th, 1970, no movement was recorded in the area of Fuorigrotta-Bagnoli, while a medium upheaval of 1 centimetre occurred in the area La Pietra-Serapeo. In the following months there was a considerable decrease in the rising speed rate, which for the period from October 10th to November 11th, 1970, was of only 0.44 millimetres per day, in the Gerolomini-Pozzuoli area.

The rising movement manifested itself along a coastal arch of about 15 kilometres from Bagnoli to Capo Miseno, with the maximum intensity in Pozzuoli. In Punta Epitaffio, on the outskirts of Baia, the upheaval of the land was only 7 centimetres, that is, almost one tenth of the measurement taken in Pozzuoli on the same date.

The existence of under-water fumaroles along the entire arch of the Pozzuoli Gulf, particularly in the area of Baia, as well as some subsiding bradyseism on the island of Ischia (where the land sunk about 15 centimetres from 1961 to today) lead us to believe that the phenomenon extends itself also to the underwater area in front of the Flegrea valley.

The uplifting of the land was accompanied by an increase in the "thermality" of the area and by a series of quakes and microquakes. New openings occurred in the Solfatara area, while numerous fumaroles were noticed in the Pozzuoli Gulf at a depth of about 40 metres, in the epicentral area of the subsequent seismic shocks, at about 1.5 kilometres from the coast. The thermal waters of Baia increased in temperature from 45° to 55° C.

These phenomena of volcanic nature resulted in seismic movements, though they cannot be classified as seismic phenomena, according to the classical meaning of the term. In fact, the area was relatively limited (the seismograph in Pozzuoli not always recorded the shocks which were recorded in Baia, and vice-versa). In Pozzuoli the recordings of the quakes located the foci at a depth varying between 500 and 1,500 metres from the surface, with an epicentral area placed in the sea in front of the Pozzuoli Gulf coast, between Bacoli and La Pietra.

The fact that the Flegrea area was affected by intense post-volcanic phenomena leads us to believe that bradyseism is another manifestation of local volcanism. Both the bradyseism and the seismic movement of the Pozzuoli surroundings are linked to the hyposuperficial magmatism which in the remote and recent past — in the three eruptive cicles which followed one another from the end of the Pliocene era to 1538 — resulted in numerous craters amongst which the Solfatara (an explosive volcano in a dormant phase), the Astroni, Agnano, Campana, Soccavo, etc...

The inversion of the bradyseism, the abnormal rising speed rate, the recording of numerous seismic shocks (211 measured by the Vescovado di Pozzuoli seismograph from March 1st to May 26th, 1970), and the possibility of seismic or eruptive manifestations endangering the population (the medium population density of the area is of about 2,500 inhabitants per square kilometres), resulted in a series of studies and measurements carried out both on the emerged terrain, and on the sea-bed.

Tidal gauges, heat flow meters, instruments for bathymetric, magnetometric, thermometric measurements, and seismographs were installed. The latter were placed in Vescovado di Pozzuoli, in Baia castle, in the Cocceio cave near lake Averno, in Capo Miseno, and on the Vesuvius. Tests were carried out on sea-water, sediments and gases, and echological studies were made, mostly regarding sea biology.

In some areas of the world, and in certain periods of time, similar warning signals have been followed by volcanic explosions or by earthquakes, while at other times, new — but dynamic — equilibriums were attained, and no catastrophic event took place

Most experts agree that a paroxistic development of the phenomenon would be preceeded by a series of seismic shocks, of growing frequency and intensity, which would enable the population to avoid disastrous consequences.

The phenomenon in progress has further damaged numerous buildings in the area, the greater part of which were already delapidated, both because of age and of the previous movements of the land.

The most widespread damages were to the buildings in the old part of the city, in front of the harbour, and in buildings below the Terra embankeent, where the maximum uplifting occurred.

For an overall view of the event, we shall briefly mention some of the theories concerning the genesis of the Campi Flegrei bradyseism, which is a problem that is still unsolved.

The theory according to which there exist great magmatic masses, alternatively in contraction and in expansion, is justifiable when a slow rising movement is followed by an eruptive event with a subsequent rapid subsiding movement. The 1538 eruption, on the contrary, was followed by a notable and rapid uplifting of the land, in contrast with the decrease of the magmatic tension which would have been expected. The theory, according to which the rising movement occurred entirely before the eruption, does not seem to explain the disproportion between the considerable accumulation of energy which provoked the rising movement, and the relatively modest proportions of the eruption which formed the Monte Nuovo.

According to some experts, the problem should be placed within the broader framework of the volcanic and tectonic evolution of the entire eruptive and sedimentary Campania basin. The eruptive centres develop along the marginal fracture lines of vast areas of subsidence; the various eruptive sectors of the Campi Flegrei are clearly located and separated from the direction of the substratum.

The low density of the pyroclastic products (essentially constituted by calk stone) which are found in the basin justifies the gravimetric minimum recorded in the area. These pyroclastic materials cover a system of faults characterized by two main lines, along which there are throws of considerable thickness. This explains the numerous craters throughout the area, because of the migration of the volcanic chimney through the fracture lines of the substratum.

The superficial calk stone is highly porous (50%) and has interconnected pores and is soaked with water.

The subsidence and uplifting of the land could therefore be interpreted as variations of the porosity due, respectively, to a settling and a consolidation of the pyroclastic material, and to an increase of the pressure of the fluids in the pores of the material itself, as a consequence of a more intense administration of heat from below (for example, because of the enlargement of the passages used by the volatile materials from the lower igneous masses or because of the evaporation of the watery solutions circulating in the carbonaceous rocks).

This would explain the maximum displacements in those areas where the power of the strata of the pyroclastic products is the greatest. (About 3.5 kilometres).

The seismic shocks which frequently follow the vertical displacements would be produced by the crushing of more or less extended sods over the porous stratum.

Local earthquakes could also be provoked by the ascending movement of the igneous masses, as was the case between 1535 and 1538, before the eruption of the Monte Nuovo.

Surface phenomena, such as for example water ejections, would mean that after the occurrence of earthquakes there are variations of flows in the water strata, and a possible contribution to the uplifting to the ground.

THE SEISMIC PHENOMENON OF MIGNANO MONTELUNGO

Mignano Montelungo, a centre in the northern part of the province of Caserta with about 3,500 inhabitants already affected by numerous earthquakes in the past, is undergoing a seismic crisis since September 1970.

The seismic period began with the shock of Septmber 27th recorded by the I.N.G. Observatory of Monte Porzio Catone (Rome) at 7.18'.51" (G.M.T.) its magnitude was of 4.0 corresponding to an intensity — in the epicentral area — of the VII degree on the Mercalli scale.

The estimated epicentre was South of Mignano in the intersection zone, between a fault which follows the direction of the Appennines and which affects the western side of Mount Cesima, and a fault perpendicular to the Appennines which passes North of the volcanic system of Roccamonfina, as can be seen in the enclosed graphic map, and as shall be pointed out later. The focal depth was calculated as being between 5 and 6 kilometres.

About 800 quakes of lesser intensity followed the main shock (up to January 31st, 1971). These are listed in the following table, subdivided according to the degrees on the Mercalli scale.

Month	II	III	IV	V	VI	VII
September		3	3			1
October	153	22	6	6		
November	470	29	10	5	2	
December	61			2		
January	4	2	3	1		
	588	56	22	14	2	1

Various Institutes were active "in loco", installing an accelerograph network and seismic stations for the study of these phenomena.

Their activities were useful in gathering study material for the characterization of the seismic period.

A first study is being published in the Geophysics Annal, edited by the National Institute of Geophysics. In this study — besides the determination of the epicentral co-ordinates, and of the focal depth (always of about 5 kilometres) for some of the most intense after-shocks — the relationships between the magnitude, the energy, and the intensity at the focus for the area and for the above mentioned focal depth are reported.

The accelerograph network has been useful in obtaining accelerograms for some of the after-shocks, thus enabling us to ascertain the relationship between energy and maximum acceleration, and to calculate response spectrums for the first time in Italy.

We report the recording, duly magnified, obtained by a M.O.2 accelerograph placed in the basement of the town-hall of Mignano Montelungo (shock magnitude 3.15, corresponding to the V degree on the Mercalli scale; focal distance about 6 kilometres).

A study of the seismicity of the region shows that from 1885 to today there have occurred 16 earthquakes, and precisely: 7 of the VII degree; 7 of the VI degree; 1 of the V degree; 1 of the IV degree. The focal depth was never more than 10 kilometres and was therefore always the first stratum of the earth's crust. The propagation of energy on the surface, such as results from the isoseismal lines of the various events, is always slight and follows a direction mainly coincidental with the Appennines. This rule is also valid for the last seismic period, of which we list the isoseismal lines; the direction of the maximum propagation follows the Peccia river valley, which is characterized by pyroclastic soil with a discontinuous detrital covering.

The calcareous area which surrounds the site is located within the confluence of faults of limited extension. It can be said that Mignano Montelungo is affected by two geological phenomena, connected with the regional and local situation: "the fault of the high course of the Volturno", and the one called" of Roccamonfina.

The first fault, running North-South, is constituted by a great fracture line, along which the rocky masses continuously move and are crushed. This fracture line originated in very ancient times, and gave birth to the volcanic complex of the region where the greater part of the centres affected by the present phenomenon are located. It permits the magma to rise from the deep strata of the subsoil, and to expand on the surface, forming the wide cone — more than 1,000 metres high — which rises near Roccamonfina.

Even though the eruptions have long since ceased, recently some gaseous explosions have occurred, as can be inferred from the innumerable small craters existing in the area.

The second fault has the same characteristics of the first, but is of less importance.

In order to have a complete view of the seismic phenomena of Mignano, it is necessary to point out that, very likely, another element of tectonic origin must be added to the above mentioned geological phenomena.

In fact, the calcareous deposits have been intensely affected by the orogenesis of the Appennines, and the subsequent orogenesis created different systems of faults, or planes of clastic diplacements. The four systems of faults, which have affected the calcareous massifs following the orogenesis of the Appennines became, joined in the Mignano area, where the epincentres are located.

This theory is strengthened by the fact that the quakes which have occurred in the Appennines have been mainly of a tectonic type and their foci were almost always located in the calcareous masses, which, owing to their rigidity, react against tensions with fractures or rapid movements along the already existing planes of clastic displacement.

In this case, the particular phenomena of the quakes (repeated paroxistic crises), the confluence in that area of the four systems of faults, and the existence of several foci lead us to believe that the calcareous masses dislocated in blocks and limited by faults are acquiring a new equilibrium. As a consequence, it is possible to say that after the first movements along one or more planes of clastic dislocation, other neighbouring masses are attempting to attain a new equilibrium.

The present phenomena fall within the range of normal events, and their occurrence must not be considered exceptional, as was — unfortunately — the case for the quake of January 1968 in the Belice valley, in Western Sicily, an area which until then was considered safe and immune from seismic dangers.

The vibrations induced by the phenomena caused damages to the greater part of the old buildings and to those already in precarious conditions, both in Mignano and in the other Communes of the macroseismic area.

Mignano has long been included amongst the Communes classified of II cathegory (rules on the constructional standards for seismic areas, which we shall mention later), but the greater parte of the existing buildings — those which were most damaged — were not built according to the appropriate earthquake-resistant standards, owing to the fact that they were built long ago.

The new buildings, built according to the earthquake-resistant standards, have up to now withstood the numerous shocks of these past years.

THE EARTHQUAKE IN ROMAN TUSCIA

The zone affected by the earthquake of February 1971 lies in the pre-Apennine Roman Tuscany region bounded by the Tyrrhenian Sea, the River Fiora, and the lower course of the Tiber. It belongs to the provinces of Rome and Viterbo. The zone is of volcanic origin: in fact, the Volsini, Cimini and Sabatini mountain chains are extinct volcanoes while the lakes of Bolsena, Vico and Bracciano are but ancient craters.

Seismic zones can be demarcated in Roman Tuscia where earthquakes have at times reached considerable intensity (up to the VII degree ou the Mercalli scale), although they usually affect relatively small areas. One of these zones falls in the territory surrounding Lake Bolsena. In fact, in the north-eastern part numerous epicentres of earthquakes occurring during the last century have been localized. On the basis of these data, Baratta classified its seismicity as between medium and intense.

To the south-west of Lake Bolsena, a seismic zone has been located at Ischia di Castro (earthquakes of 1889 and 1909). With the exception of the earthquake at Tarquinia in 1819 and that at Tuscania in 1881, no other earthquakes had been noted in this zone in the past.

More recently, in July 1969, a seism of VII intensity on the Mercalli scale (magnitude 4.31) occurred, its epicentre being in the Tolfa Mountain district.

The epicentre of the February 1971 earthquake was located in the outskirts of the town of Tuscania (Viterbo). The first shock occurred on the sixth of the month at about 7.09 p.m. and, according to the records of the National Institute of Geophysics Seismic Observatory at Monte Porzio Catone (Rome), had a magnitude of 4.46 and an epicentral intensity of the VIII degree on the Mercalli scale. The second shock, also of notable intensity, occurred at about 10.20 p.m. on the same day and had a magnitude of 3.56. The third shock, with an intensity at its epicentre of the II degree ou the Mercalli scale, was felt at about 5.41 p.m. the seventh of the month and was recorded at Viterbo by the National Geophysical Institute's mobile unit and at Monte Porzio Catone by the seismographs in the Oservatory. A further shock of negligible intensity was recorded on the eighth of the month by the mobile unit's seismograph.

The towns and villages in Tuscia affected by the earthquake are situated on mainly tuffaceus hills whose sides plunge steeply, and sometimes, vertically, down to the valley bottoms.

Tuscania is situated on the edge of a vast expanse of rather fine-grained, massive grey leucite tephrite. This Pleistocene lava flow, which extends over an area of about 12 km^2, originates between two blocks of flysch and runs north-south.

On the boundaries of Tuscania, Pleistocene subaerial or paludal deposits are found interbedded with a variety of vulsine and vicane volcanites (white pumices, tuffs, etc.). Finally, in the south-eastern part of the district Pliocene clay and sandy clays are encountered beneath superjacent conglomerates and sands. Roman Tuscia is affected by the fault system shown in the annexed figure.

The earthquake killed 22 persons and injured about 100 in the town of Tuscania, while about 4,000 were made homeless by collapsed or badly damaged buildings. The historical centre (which was founded in the third century B.C. while the monuments of present importance date back to medieval times) was rendered almost totally uninhabitable. Damage was also caused to a number of houses in the neighbouring villages of Arlena di Castro, Canino, Piansano and Tessennano. The seism was also in other towns in Tuscia, among them Tarquinia, Montefiascone and Viterbo.

The gravity of the damage inflicted on Tuscania can be accounted for by the great age of the buildings, mostly two — or three — storey tufa masonry constructions with badly supported timber floors, heavy vaults and with roofs borne directly by the walls.

The modern buildings, mostly sited outside the walls of the old quarter, withstood the shock and suffered only superficial damage. These are of tufa masonry construction with mixed steel or reinforced concrete floors or with skeletons in the same material and tufa plugging.

Earthquake-resistant standards were not used in the construction of these buildings since the seismicity of the area was not considered sufficient to warrant them.

The concentration of the ruins over a small area indicates that the focal depth was only a few kilometers deep. The shallow depth of the focus is in keeping with the characteristics of the area, which is affected by tectonic activity peculiar to hinterland zones connected with the Apennine orogeny.

5. INFORMATION ON ATTEMPTS TO FORECAST SEISMIC PHENOMENA

The proceedings of these study sessions also include a discussion on forecasting earthquake disasters. Accordingly, it seems appropriate to make some reference here, however vague, to present trends.

To be able to forecast the probability of an earthquake occurring, an accurate knowledge of what occurs inside the earth is required. The difficult problem posed is that of determining the time and place in which an unknown stress will be released and overcome the resistance of the earth's crust, this also being an unknown quantity.

From the remotest times this problem has interested man. Traces of the studies made in Ancient Greece have come down to us in the writings of Anaximander and Pherecydes. Seneca (4 B.C. - 65 A.D.) in his "De Terrae Motu" concluded with fatal stoicism that loss of human life in earthquakes must be accepted with resignation since "no part of the earth is entirely free and exempt from this risk". Pliny the Younger (62 - 114 A.D.) with the statement "where the earth has trembled once it will tremble again" paved the way for studies based on statistical methods.

In Italy these studies have reached a fairly advanced stage. Their main aim is to identify the zone where an earthquake may occur, but they supply no information as to when this event will actually happen. A forecast based on statistics is, therefore, useful to draw up constructional standards (it is not feasible, in fact to lay down constructional standards designed to withstand a shock of IX intensity if the event has low probability) and for insurance purposes. However, it cannot be used to forewarn the inhabitants or put them on the alert.

Over the span of the centuries, an attempt has been made to forecast earthquakes by studying groundwater circulation anomalies, endogenous rumblings and warning signs, without, however, any concrete results accruing.

Despite the great advances of science and technology, it must be humbly admitted that reliable and humanly satisfying forecasts on seismic phenomena cannot yet be made, although there is hope that in the future fatalistic acceptance that these calamities can in no way be foreseen may be overcome. Methods are now being studied and applied which, starting from both qualitative and quantitative geological, geophysical and seismic data, may well lead to determining the probable mechanism of the seismogenetic process in the area considered. This knowledge is fundamental for the physical forecasting of earthquakes. However, the results so far obtained, through the study of both microseisms and active faults, which constitute the two most significant lines of approach, do not permit a solution of the problem to be expected in the near future.

This problem is of particular importance to Italy, and relevant programs of research and investigations are now in progress.

Studies on the mechanism of the shock at its focus have shown that Italian earthquakes do not invariably occur along faults visible on the surface, but that they are often localized along faults existing before overthrust occurred. Moreover, further comparison with the trend of the isanomalic lines of gravity has shown that zones of seismic activity often occur in places where rapid variations in regional gravity are encountered. By uniting these data it is possible to arrive at a reasonable picture of the causes underlying the zone's seismicity. A whole series of investigations, using clinograph recordings, has been made over the last decade to cast light on the slow movements of the earth's crust and, in particular, of two blocks of different geological constitution separated by an active fault. Two clinographic stations situated in the Tolmezzo area (Eastern Alps) made it possible to observe the preparatory phase of a seismic period of by no means negligigle magnitude which subsequently occurred in April 1954.

These investigations proved that the instability of the clastic equilibrium in the zone appears under two aspects: slow movements of the earth's crust, especially along fracture lines, as recorded by clinographs, and throbbing tremors in the medium subject to deformation, as revealed by seismographs (seismic inquietude). Numerous earthquakes with their epicentre in the zone (and with shallow focal depths) were preceded by gradual variations of the vertical and by periods of seismic inquietude. Variations of the apparent vertical and seismic inquietude do not always results in a break (earthquake): their action may be sufficient to enable the strained medium to attain temporary equilibrium.

In order to devise further techniques, studies have also been started on the behaviour of active faults in the Alban Hills (Rome).

A further result concerns the influence of surface and near-surface stratification on the propagation of seismic energy. Research was conducted by two stations situated only 7 km apart, each equipped with exactly the same instruments, but situated on quite different geological formations: one a very thick mantle of sediments, the other rock. This has enabled light to be cast on the diverse behaviour of the two types of soil, a higher degree of risk being ascribed to the former than had been supposed on the basis of previous investigations conducted in other countries.

For these studies the seismic network of the National Geophysical Institute has been in the past and will continue to be of great value. This network has been operating for more than twenty years and enables a microseismic study to be made of all earthquakes affecting Italian territory, with the determination of epicentral data, depth, the energy developed at the focus, and the mechanism triggering the shock (fractures, uplifts, subsidence of strata). The clinograph stations erected by the same Institute in localities affected by particularly active faults are also of considerable value. These have been installed to study the relationship between seismicity and orogenic movements and, in the Alpine zone, have led to the interesting results already referred to.

This notwithstanding, it is felt that it will be impossible to forecast seismic phenomena for many years yet with sufficient precision to make the forecast effective. All that remains, therefore, is so-called "passive defence". This takes concrete form in constructional standards and will be discussed in the following chapter.

6. STANDARDS AND LAWS GOVERNING CONSTRUCTION IN SEISMIC ZONES

Statistics show that in Italy the annual average number of earthquake shocks is about 400. Fortunately most of these are slight although there is no lack of damaging and disastrous events.

With the exception of Sardinia, which is almost completely free from seismic shocks, earthquakes have left traces of their violence in all regions of Italy. Over the last 140 years, more than 1,000 serious earthquakes have occurred, with estimated intensities of between the VI and the X degree of the Mercalli scale, while disastrous earthquakes of the IX and the X degree intensities amount to about seventy.

The uninterrupted repetition of these calamities with high loss of human lives and vast destruction has, on various occasions, induced the competent Authorities to study preventative measures to limit the damage caused by seismic activity. (The first seismic standards in Italy date back about two hundred years).

The precautions devised to reduce as far as possible damage caused by earth movements were almost exclusively limited to those likely to increase the resistance of constructions liable to seismic stresses.

Ing. Panetti's report drawn up after the Messina earthquake of 1908 was the first technical document to tackle the problem of earthquake resistant construction. His precise observations and his brilliant insight were forerunners of the more modern trends used as basis for subsequent antiseismic regulations. The criteria followed in this report, from an overall and synthetic viewpoint, may be summed up as follows: prohibiting new and reconstructed buildings in geologically unsuitable areas; insisting on foundations being laid so as to almost root the building into the ground, thus obtaining the greatest possible synchronism between the soil and the building; respecting height limits and given constructional methods; and, finally, adopting city planning laws for the planned distribution of new buildings.

These fundamental principles, suitably amplified, form the essential part of the standards enforced by the law of 1937. A further improvement subsequently led to Decree Law N. 1684 of 25/11/62.

This law, which is still in force, laid down standards covering only a few aspects of the problem ,and is based exclusively on static criteria. One the one hand, it brings the subject into line with scientific and technological advances and, on the other, increases the penalities for non-observance of the standards, obviously in the interest of public and personal safety.

The underlying principles of the special technical standards laid down in the last above mentioned law are more or less unchanged with respect to the previous law of 1937. These principles are not based on a scientific study of earthquakes, but lacking this, on a general technical criteria of caution and greater safety.

These standards apply to ordinary building constructions. Other structures and, as a rule, constructions with mainly vertical development such as bridges, viaducts, dams and towers are also covered by the law, unless otherwise provided for under special laws.

The reconstruction of damaged buildings is understood as an opportunity and means for obtaining better conditions of stability than those prevailing prior to the earthquake, i.e. to ensure that buildings have greater resistance to withstand possible repetition of the seismic shocks.

A rider to the law gives lists which classify the Communes into two categories according to degree of seismicity. These lists may be modified by decree of the Minister of Public Works, in agrement with the Minister of the Interior, after having consulted the Public Works Advisory Board (Consiglio Superiore dei Lavori Pubblici).

The industrial expansion now in progress in the centre-south of Italy, a zone embracing the major earthquake regions, and the advent of new types of buildings, make it necessary to revise many criteria of the present law, and hence to conduct studies likely to lead to the application of new methods to at least the major building works. The need has thus been felt to revise and up-date the seismic regulations now in force and to bring them into line with the most recent international ones.

The formulation of norms for the design of structures in earthquake zones has always given rise to considerable difficulties, especially if the design is based on the so-called static method, which consists of replacing dynamic stresses by static forces capable of producing the same effects.

Most researches maintain that the problem of design should be tackled from dynamic considerations, and point out that solely knowledge of ground movements and maximum accelerations during each period (earthquake spectrum) can provide information on the actual behaviour of the structure (response spectrum), and thus effectively solve the problem.

The country's development requires infrastructure and works of appreciable height whose design entails a departure from legal provisions based on static criteria.

These considerations indicate that, whatever method is to be adopted, it is necessary to start from maximum acceleration and from the periods in which this occurs in the zone (earthquake spectrum).

The need to bring the seismic regulations up to date encountered an initial difficulty in the lack of on-the-spot surveys of Italian macroseisms.

Hence it has been considered necessary to draw up a program aimed at providing a complete picture of seismic phenomena in Italy with special emphasis earthquake-resistant construction. The instrumentation part required to implement this program consists of an accelerograph netwoork, a number of clinograph station, the seismic net and, finally, a macroseismic service.

A basic accelerograph network is now being installed by the Ministry of Public Works, the Italian National Institute of Geophysics acting as consultants. This network will consist of 110 A.R. 240 and M.O.2 type acceleropraphs which record the entire earthquake spectrum.

The utility of the clinograph stations and seismic network has already been mentioned in the Chapter on forecasting. It is advisable to stress at this point the complementary importance of the seismic network in obtaining a complete picture of the region's seismicity and thus in drawing up an efficient set of regulations.

As is well known, the development of networks of stations of this kind, equipped with ever-more sensitive apparatus and employing computer, facilitates determination of the shock epicentres. These determinations enable the seismic characteristics of a zone to be more precisely defined while recordings enable the development of the magnitude, and, consequently, the energy of the seism to be followed at all times.

In Italy, as in all countries characterized by seismicity, a macroseismic service, assigned to the individual Communes is in operation. On the occasion of each event the Commune fills in a questionnaire on the damage caused to buildings. The National Institute of Geophysics assesses the degree of the shock and traces the isoseismal lines of the earthquake.

When events of major intensity occur, a geophysicist belonging to the Institute usually makes a series of direct on-the-spot surveys. From a comparison of the data thus obtained with those recorded in the same circumstances by the accelerograph network, correlation factors can be determined to permit a more rigorous evaluation of material referring to previous years, material indispensable if a reliable documentation on the seismicity of the various zones in the Peninsula is to be obtained.

To hasten the up-dating of the seismic regulations, the committee set up for the purpose within the Public Works Advisory Board (Consiglio Superiore dei Lavori Pubblici) has made a statistical study of seismic surveys conducted in other countries. This study has provided a sufficiently acceptable picture on which to base the approach for calculating earthquake-resistant structures.

It must be pointed out, however, that this approach to the problem has made it necessary to give to the proposed regulations sufficient flexibility for them to be up-dated later on the basis of the seismograms supplied by the accelerograph station network now being prepared.

The flexibility of the regulations also meets a need felt by all technical legislation, i.e. that regulations can be brought up to date in pace with the constant advance of science.

It has thus been deemed advisable that a new law, now awaiting approval (as has already been granted to the law on plain and prestressed reinforced concrete buildings), should lay down the general concept only, leaving it to subsequent Ministry of Public Works decrees, taken in accord with the Ministry of the Interior, to specify what particular techniques are most liable to changes stemming from advances in science and technology.

The framing of the previous regulations will be changed, since many of the previsions contained in Law N. 1684 are no longer included therein.

The variants proposed mainly concern the classification of seismic areas, height limits — and consequently the framing of calculations to verify the structures —, the elimination of gaps, the need for joints and more precise and stricter standards for the foundations and for the necessary soil mechanics investigations of the ground on which such foundations are to be laid.

In particular, classification of the seismic areas into two categories has no longer been retained. Instead a greater number of areas with grades of seismicity varying between 7 (present IInd category) and 12 (present Ist category) have been considered.

The subdivision into a greater number of categories will be made gradually as the seismic and geotechnical studies in Italy are extended. These studies have already been programmed and are now being conducted by the Ministry of Public Works.

As for building heights, the impediment of having inadeguate knowledge of seismic phenomenon has now been overcome, and in particular that relating to the behaviour of structures under the dynamic action of the shock itself, it is felt advisable to provide for the complete freeing of height restrictions, accompanying, however, the vertical development of the structures by evermore thorough calculations in keeping with the trend of seismic phenomenon.

On the other hand, a limit has been kept on the height of masonry buildings and those with load-bearing panels. For the former this is because of their low resistance to seismic action, and for the latter because adeguate documentation ad experience on their behaviour in earthquakes has not yet been acquired.

However, the complete abolition of height restrictions on reinforced concrete and steel skeleton buildings entails the need for ever more accurate calculations as the height of the building increases. Whereas, in fact, for lower buildings a static calculation of the structure is required, for higher buildings the choice is left to the designer whether to proceed with a static calculation — with horizontal forces becoming greater and greater as height increases -- or to calculate the proper period of the building and proceed with the dynamic calculation of the structure with minor seismic forces.

The technical safety criteria on which the new norms are based make the special discipline regarding gaps superfluous. On the other hand, the placing of adequate joints between one building and another is required so as to avoid impact between them during vibration of the buildings in an earthquake.

Foundation problems have been standardized, precise instructions being given on the soils mechanics investigations required and on criteria chosen for the structural calculation. This is of fundamental importance for the stability of the buildings, since inadeguate knowledge of the mechanical characteristics of the soils and a faulty foundation design can compromise the stability of the whole structure, even thorugh its above-ground parts are designed and calculated using the most advanced methods known to science.

The subject will be reported more fully during the general discussion.

Apart from what has already been said it may be of interest to note that investigations are also under way on the behaviour of construction materials and of structures in earthquakes.

These studies are being conducted, with coordination by the National Research Council, at various University research centres as well as at the Model and Structure Testing Institute (Istituto Sperimentale Modelli e Strutture - ISMES), Bergamo. The results obtained are examined periodically at study conferences and will be used in drawing up the new measures envisaged by the above-mentioned law now being approved.

7. STATE AID

During the recent earthquakes, the Italian Government acted in a much more concerted way using all available means to rush first aid to the stricken inhabitants, in order to alleviate their suffering, and later to revive the economy of the destroyed or damaged towns and villages. The Government's work, as will be seen in greater detail further on, thus followed a two-fold approach: rescue operations and rebirth of the stricken areas.

(a) *Rescue operations*

The first aid and rescue services were organized so as to intervene as rapidly and, at the same time, as effectively as possible in line with the needs of the localities hit by the calamity.

On the basis of Law N° 969 of December 8, 1970, "Regulations on First Aid and Assistance to Inhabitants Stricken by Calamity", the duty of organizing Civil Defence in normal times in entrusted to the Ministry of the Interior which acts in accord with all the other Authorities and Agencies concerned.

When a calamity occurs, the Ministry of the Interior is also called upon to direct and implement coordination of all activities carried out in the circumstance by Government and Regional Authorities and by territorial and institutional agencies.

Furthermore, the Ministry of the Interior draws up and implements the measures necessary to ensure essential technical services and first aid. It also sees to the performance of works of immediate necessity and to supplying the equipment needed for the inhabitant's protection. Finally, it equips and trains volunteers for the rescue operations.

The emercency technical measures are carried out by the National Fire Brigade (Corpo Nazionale dei Vigili del Fuoco) in which special squads called "Zonal Mobile Units" ("Colonne Mobili di Zona") have been set up for rescue operations. There is one of these units for each of the twelve Civil Defence Inspectorates into which the Italian Republic has been divided, as well as a "Central Mobile Unit" ("Colonna Mobile Organica") with headquarters in Rome.

The task of these Mobile Units, each equipped with about 80 motor vehicles, is that of carrying out emercency mass rescue operations in all major calamities.

In addition to the system of Mobile Units, for Civil Defence operations of particular magnitude it is possible to call on helicopter and diving squads, as well as on a "Central Rescue Squad" ("Nucleo Centrale di Manovra") consisting of personnel attending instructional and training courses at the Central Fire-Fighting Schools (Scuole Centrali Antincendi) — trainee regular firemen, trainee national-service firemen, non-commissioned-officer trainees, etc. — which can be speedily mobilized at any time and rushed to the scene of the disaster .

Within the framework of the Civil Defence measures must also be included the "Public Rescue Squads" ("Reparti di Soccorso Pubblico") organized and equipped partly by the Public Security Department and partly by the Carabinieri, and stationed so that a squad is present in each Civil Defence zone.

The whole of the country is, thus, able to benefit from these auxiliary rescue agencies, specially equipped both to provide first aid to the stricken inhabitants by setting up casualty stations and rest rooms, by distributing drinking water and by putting up tented camps for those requiring urgent assistance, and to distribuite emercency meals and, if required, isolate the stricken zones.

"First Aid Centres" ("Centri Assistenziali di Pronto Intervento") then provide more extensive aid in favour of those stricken by the disaster. Twelve of these Centres have been set up by the General Directorate of the Public Assistance Department of the Ministry of the Interior. They are also appropriately stationed throughout the country so as to provide one Centre in each Civil Defence area. There are also "Emercency Centres" ("Centri di Emergenza") belonging to the Italian and International Aid Authorities.

Further information on the organization of rescue operations in case of public calamity will be given during the course of the discussion to be held by the scheduled working group.

(b) *Operational measures*

Directly after getting over the first stage in which timely rescue operations are required to meet the immediate needs of the stricken inhabitants, and to limit the worsening of the damage caused by the earthquake (removal of rubble and strengthening or demolition of damaged buildings imperilling public security), it is necessary to provide shelter for homeless families and to repair utilities and services essential for the life of the stricken populations.

The information obtained immediately after an earthquake does not, as a rule, correspond to the actual situation. The first problem then is to ascertain the extent of the calamity, the number of towns and villages affected, and the number of casualties according to age, economic status and occupation.

The investigation takes concrete form in ascertaining the number of dwelling houses industrial and commercial buildings and workshops destroyed and either seriously or superficially damaged.

Once the extent of the disaster has been established, Government measures are tailored to it, through the issuing of legislative instructions which stipulate the appropriations and other steps required.

It is certainly not easy to find the best system to remedy all the damage caused by a telluric event of extensive proportions, so the Government acts case by case, in relation to the degree of destruction wrought.

The most serious problem is that of finding suitable accomodation for those inhabitants compelled to leave their own homes. It is not always possible to accomodate homeless families in other premises (schools, hotels, private houses), so that recourse must be had to tented or hutted encampments. Considerable financial and technical resources would be necessary for the expropriation of the areas needed to install all the services required for community living.

There is no doubt that community life of an insecure and temporary kind is distressing for the inhabitants. Prefabricated accomodation would be preferable since it enables the homeless to be more comfortably housed. This solution, however, is not always feasible since the material needed is not usually available on the market at the short notice and in the quantities the situation demands.

In some cases there is the difficulty that the areas chosen for temporary settlement, whether in huts or prefabricated houses, must later be used for settlement of a final nature, especially in cases where it is impossible to find other geologically secure areas.

Later it is necessary to take measures to restore the conditions prevailing before the disaster and, at the same time, to apportion the assistance measures to enable the rebirth and reconstruction of the areas devastated by the earthquake.

The Government direcly bears reconstruction costs of public property whereas for privately-owned property, and in particular, for housing units, the Government makes grants in proportions to the value and size of the damaged or destroyed building or to the income obtained therefrom by the owner.

Usually when the earthquake leads to the destruction of entire inhabited centres or a large part thereof, an endeavour is made to give the stricken area a new, more modern layout thorugh the creation of fresh housing centres.

The need for this has been apparent since the 1908 earthquake which destroyed the two cities of Messina and Reggio Calabria. Such a scheme was implemented after the Avezzano earthquake of January 1915, the Irpinia earthquakes of July 1930 and August 1962, and of the Western Sicily quake of January 1968.

In these circumstances the Government has drawn up reconstruction plans, taking care that the new centres should be sited on geologically safe areas and that the infrastructure needed for a better planned layout of the centres themselves was created not least in relation to the employment possibilities already existing or to be opened up in the immediate vicinity of the houses.

Provision has also been made for the primary and secondary facilities needed for the new centres (roads, water supplies, sewers, electrical installations, schools, outpatients' clinics, markets, public buildings, etc.). Usually industrial zones are planned at the side of the newly built housing estates to foster the development of economic and productive activities upset or compromised by the earthquake.

This criterion has given the best results since it has enabled settlements to be realized by using the most modern building systems, and by applying the standards laid down for earthquake-resistant construction.

Unfortunately the erecting of housing centres holds back reconstruction activities not only on account of the time necessary to identify the areas and to draw up, and obtain approval for, the reconstruction plans, but also because of the opposition at times shown by the inhabitants concerned, who, for either sentimental reasons or for economic interests, or both, are reluctant to move to other areas.

The Government also provides, through special Agencies or Institutes, for the construction of accomodation for needy person who were not house-owners.

The total costs for assistance work, reconstruction and various indemnities resulting from a serious natural calamity amount to a considerable sum which weighs heavily on the country's budget.

The telluric disturbances which have occurred in recent times in various parts of the world lead to serious consideration being given to the need for setting up a permanent international agency having, inter alia, funds available to go to the aid of countries in cases of public disaster, thus providing a guarantee of human solidarity in favour of the stricken populations.

8. POINTS PROMPTED BY EXPERIENCE

The previous description of earthquakes that have occurred in Italy over the last ten years, with their numerous victims and enormous destruction, has led to the formulation of a number of points.

The problems arising when analysing earthquakes are both many and complex. Here an endeavour will be made to identify some of these and to suggest precautions to be adopted particularly with regard to appropriate technical measures, to limit damage and to avoid loss of human life as far as possible.

For the protection of the inhabitants the following are of signal importance:

- Further study and improvement of compulsory constructive standards to be applied in seismically instable areas;
- Fuller understanding of informative data, as far as these can be reliable, on forecasting seismic phenomena;
- And finally, the rapid availability of all items needed for rescue operations in line with the disaster whenever this occurs.

Past experience enables it to be stated that more than 90% of the losses in human life due to earthquakes, and much more than 50% of the damage to buildings, are due to the buildings affected by the seismic shock offering little resistance or even being already in a dilapidated state (even slight subsidence of the foundation soils or external movements would probably have damaged them). In fact, it is noted that:

- Load-bearing wall constructions, even if with mixed reinforced concrete floor slabs, when made of poorly constructed masonry cemented with weak mortar, with their roofs directly supported on the walls, and roughly laid foundations, have suffered the greatest damage since they offer no resistance;
- Well designed and built bridges and viaducts, with solid foundations have hardly suffered at all from the seismic shock;

- Reinforced concrete structures, even if of great height, have withstood seisms of considerable intensity; a number of reinforced buildings, although cracks have appeared in the putting and structure (usually because of poor design), have not collapsed, thus ensuring the safety of the people living in them.

These few remarks show the marked increases in safety that can be obtained by scrupulous compliance with sound building techniques, by using better and more resistant materials and by employing a higher technical level in actual execution.

In the preceding paragraphs, present trends in Italy regarding the new basic criteria for the design of structures in known seismic areas were discussed. However, even in aseismic areas it is advisable to prevent inadeguate systems and materials being used for building or reconstruction.

Public utilities in the stricken centres have been almost completely paralysed on a number of occasions because of broken power cables, telephone lines, water mains, etc.

In this important sector greater consideration should be given to constructional and design precautions to ensure the operation of water supply mains, oil pipelines, power transmission lines, etc., even in the case of earthquakes. Special care should be devoted to preventing those complications occurring which in some circumstances can cause greater damage than that brought about by collapsing buildings.

In designing these plants it is advisable to follow these general criteria:

- Construct the installations on solid, uniform foundations, while those of particular importance, of greater vulnerability, which are difficult to identify and to repair after damage, should be constructed in separate units (and endowed with emergency equipment);
- Chose suitable materials (iron, steel, reinforced concrete, etc.);
- Use earthquake-proof joints between elements of vastly different rigidity;
- Make a preliminary study of the environmental conditions in order to avoid damage to installations through collapses, subsidence and displacements in the surroundings, or otherwise provide protective works;
- Take special precautions regarding essential installations, such as pumping plants.

Because of entirely fortuitous circumstances, no serious fires have broken out following recent earthquakes. This can be accounted for by the fact that buildings have usually only collapsed in built-up areas consisting of masonry constructions devoid of inflammable gas installations and premises storing large quantitites of inflammable materials.

While it is obviously impossible to prevent fires breaking out during earthquakes, it is certain that, by scrupulously complying with appropriate precautions and anti-fire norms, particularly regarding resistance to fire, fireproof structures, and the suitability of the premises, depots and installations with regard to inflammable materials, it is possible to attain a satisfactory degree of safety, thus cutting down as far as possible fire risks to persons and property.

Among the geological phenomena which often accompany erthquakes mention must be made of landslides, which sometimes make the damage suffered by the inhabited centres more serious and calamitous. In this respect landslides which occurred on the loose soils of steep hillsides following acceleration due to the quake, must be mentioned (events of this kind were recorded at Irpinia and in Sicily).

Earthquakes have often caused cracks and subsidence in the soils (in Sicily they effected an area of about 6 km on State Highway 119 which leads from Alcamo to Castelvetrano).

Unfortunately our country is afflicted with a high number of landslides, which are triggered off by many causes, and which alone can amonut to a public calamity. This has led to the need being recognized for studies to be started on the compilation of seismic risk maps in relation to the composition of the soil ("regionalization" maps as Richter suggests) which would enable possible damage from earthquakes to be determined.

For an ever deeper analysis of seismic phenomenon, an appreciable contribution to progress has been made by the intensification of theoretical studies and experience, by improved techniques and measuring and recording apparatus, and by the adoption of modern computers.

It is essential to allow for the fact that an earthquake disaster is always accompanied by a series of aftershocks which can lead to further structural damage and to landslides where soils have been made unstable by the first shock. From this springs the need for qualified experts equipped with suitable instruments (seismographs, accelerographs, etc.) to be sent to the spot to evaluate further developments of the phenomenon so that precautionary measures can be taken, if required.

To this end the National Institute of Geophysics has set up a mobile unit which, with the agreement of the Ministry of Public Works and the Ministry of the Interior, will intervene in all particularly serious events.

The unit is made up of a three-component seismic station and four acceleropraghs of the same type as mentioned previously. Similar equipment is being installed at the Observatory of Experimental Geophysics in Trieste.

After a shock of notable intensity, it should be possible to establish almost immediately the magnitude and epicentre. This would be done through an efficient organization of the various observatories, which would ensure the seismograph and accelerograph data to be rapidly examined and processed.

The rescue operation carried out in 1968 for the inhabitants stricken by the earthquake in Sicily can be considered the most difficult tackled during the last decade. As we have had occasion to note, various towns and villages of two provinces (Trapani and Agrigento) were disastrously involved in an area on the extreme limits of the Country, and on an island in the bargain.

In this doleful event, which grievously afflicted the whole Nation, extensive use was made of manpower, machinery and other equipment geared to the magnitude and nature of the services required.

The rescue operations took slightly more than two months and covered various stages: the first and most important of these from a human point of view was life saving. In fact, in the villages and towns stricken by the earthquake 606 persons who had been trapped by the masonry of collapsed buildings were saved, mainly because of the rapidity with which the rescue workers reached the area. The spirit of abnegation which inspired them in their efforts, despite the continuation of shocks and falls, knowing that possible delays would doubtless increase the number of casualties, was altogether praiseworthy. The dead amounted to 249.

The other stages of the initial operations were clearing the roads, the search for bodies, and recovering animals, household effects, valuables, documents, etc.

When the work had been completed, special study meetings on, for instance, the experiences and future prospects of the Civil Defence Organization, focused attention onto the important questions that had emerged, and indicated possible solutions aimed at improving efficiency.

For the purpose of this, only a few essential indications of a general kind will be given. Further details can be provided later during these proceedings when matters relating to rescue work and emergency operations are being dealt with.

Experience has revealed that, especially when a number of inhabited centres are stricken by powerful shocks covering an extensive area, rapid information regarding the demarcation of the territory, the possibility of transit over the access roads, and the condition of the public services is of the utmost importance.

If account is taken that telephone, telegraph and power transmission lines in these localities remain interrupted by the damage, and that notable difficulties prevent the extent of the disaster being known, the value of using helicopters in these circumstances (unless there are operational restrictions; at night coloured flares could be used, etc.) will be readily appreciated.

Helicopters provide rapid information through radio links and possibly through photographs and television pictures, while, at the same time, they can, during the first, more intense phase of the rescue operations, evacuate the injured and supply other pressing needs.

The availability of airphotographs of the affected zone (in this case an organization specially set up for the purpose would be used with the cooperation of services provided by the Italian Air Force) before and after the disaster, would obviously offer better and more extensive opportunities for appraisal and documentation.

The importance has also been noted of problems related to organizing transport of the numerous personnel, of machinery needed for the various operative sectors and of rescue materials, as well as that of installing logistic services in the temporary base camps. The latter was to ensure the greatest possible assistance to the personnel and, at the same time, see to their timely dispatch to the areas stricken by the disaster.

In these circumstances advanced planning of the methods to be used in the various operations involving air, sea and land (rail and road) transportation, and effective coordination for implementation, have been shown to be essential.

The relief of the zone, surrounded by hills, and the layout of the inhabited centres on hillside terraces, imposed the installation of appropriate radio relay links. The latter proved indispensable for the purpose of rapid communication between the control centre, the rescue sectors and the operational units. These radio facilities, flanked by direct telephone lines with the Ministry of the Interior Control Room in Rome, enabled developments in the situation to be immediately ascertained and units to be promptly sent to the zones where need for them was most strongly felt.

Track-type wehicles, front-loaders, and dumps trucks were of great help in opening up the roads to traffic in order to enter districts where there were large quantities of rubble, or to knock down unsafe buildings which would otherwise have collapsed causing further victims.

To alleviate the suffering of the disaster-stricken inhabitants one of the most urgent needs was to set up tented camps. The criteria of implementation, and the difficulties encountered because of the peculiar conditions prevailing, as well as other important related question, will be mentioned in later reports.

The rescue operation carried out in this serious calamity, while consolidating the links of active and generous cooperation between the various units under the Ministry of the Interior and the civil and military authorities — wherever these were employed — confirmed once more the need for all the operative forces to be coordinated by a single Control and Organizing Centre.

This requirement has found application, as already mentioned elsewhere in this paper, in the official regulations recently issued for the Italian Civil Defence Organization.

On the basis of the points considered so far, it is possible to gather the multiple problems which arise when an eartquake disaster occurs: some have been mentioned, others omitted, for the sake of brevity or because they will be more appropriately placed in particular subjects envisaged for the proceedings of the Symposium.

At the end of this first paper, we confirm our firm undertaking to make every effort to reach possible solutions for reducing earthquake risks even if, unfortunately, we are faced with a natural calamity that cannot be prevented. Man can only defend himself from it by putting all his skill at the service of the Community to safeguard lives and property.

The Value of Historical Records of Earthquakes

by N. N. Ambraseys

It is now recognised that any hope of earthquake prediction rests on increasing knowledge of earthquakes and their causes as well as of their effects. Almost all estimation of seismicity is probabilistic in content and these probabilities may be computed from observed occurrences of earthquakes. Yet the length of time that seismological data cover is negligibly short when compared with the geological time scale that is involved in the seismicity of a region. In a sample of given period of time, small events are more numerous than large earthquakes which are important but rare events and as such are not easily counted unless the period of observation is large. Thus, in spite of the considerable volume of data for earthquakes of the last century, the period of observation is too short to permit a meaningful statistical treatment to be effected.

Our earthquake records extend over a much longer period than this and for the stronger events we may claim some degree of homogeneity for the last 20 centuries.

The region chosen for study comprises the area between 10° to 45°N and 20° to 60°E. In assessing the value of historical data prior to 1700, we resorted to original sources of information, written not later than two centuries after each earthquake, and we avoided using modern works. Contemporary correspondence, manuscript marginal notes, colophons, synaxaria, inscriptions and archaeological data were also used. Our scheme has been to make an absolutely fresh collection on contemporary evidence alone, in which earthquake events should be set forth in an account of the local history. The reason for this thorough review is that most of the existing earthquake catalogues were found to be unreliable for the period prior to 1800 (1). These catalogues were based on modern works and on early sources of information at third hand. For instance, 65 per cent of the entries in Sieberg's list (6) for the period prior to 1700 were found to be wrong. His list has been copied by many others without checking the mistakes, which are now being repeated from publication to publication.

The material available at the moment is coherent enough to permit some conclusions to be drawn about the historical and scientific value of early earthquake records.

A typical, though not the best example of early seismicity, is that for the region of Istanbul. Figure 1.a shows the time distribution of all strong earthquakes that caused alarm and also some damage in the city. From this figure we notice two conspicuous periods of relative quiescence, each about 200 years long, centering on the 7th and 12th centuries respectively. These are periods of genuine inactivity and are not due to lack of information. As a matter of fact, the second of these periods coincides with the period of the Crusades for which we have the largest amount of information from occidental sources. From the same figure we notice that the frequency of occurrence of strong earthquakes in the 5th and 6th centuries is the same as that for the period after the 15th century. Figure 1(b) shows a similar plot for shocks that caused wide-spread concern over a large area and also considerable damage in Istanbul. Long periods of quiescence are again noticeable, but also groups of strong earthquakes, marking distinct increases in seismicity, with an average rate of about one damaging earthquake every 55 years. Finally Figure 1(c) shows the distribution of destructive earthquakes that ruined large parts of the country around Istanbul, causing heavy damage with large numbers of casualties in the city itself. Some of these shocks were followed by comparatively short periods of high seismicity which often occurred near the end of long periods of relative quiescence; most of these large shocks were associated with seismic sea-waves, a number of which were of catastrophic magnitude.

Frequency curves, similar to those shown in Figure 1, have been prepared and studied for a large number of regions. They show that earthquake frequency is subject to marked fluctuations rather than to any general monotonic variation. They show also that the data available for the last 20 centuries are sufficient for the detection of secular changes in local seismicity but inadequate to establish whether these changes are subject to a law. It is our impression that historical data are useful for the study of the migration of seismicity in contiguous tectonic units and for other correlation studies including seismicity. For prediction purposes, however, a much longer period of observations is needed, for which no foreseeable means of data gathering seems likely.

Faced with a high degree of uncertainty, but pressed by the requirements of a technical society for judgement and decisions, seismologists and engineers make daily estimates of seismicity with varying degrees of success. The study of historical earthquakes brings out two important points that should be taken into consideration when early events are used in seismicity assessments.

The first point concerns the interpretation of early earthquakes. To each of the curves shown in Figure 1, or to any other frequency curve, corresponds a particular Intensity, the precise value of which cannot be assessed. The reason for this is that Intensity, being a measure of the effect of a particular earthquake on modern man-made structures, cannot properly be used for early events. Modern buildings differ in many respects from old ones and to judge future damage from centuries old case histories can be seriously misleading. The exact repetition of an old earthquake at the present day will differ not only in the types of structures damaged but also in the degrees of damage. For instance, a distant large earthquake ten centuries ago should have caused practically no damage in Istanbul. The same earthquake today will cause damage to a large number of long-period structures in the city.

The second point concerns the assessment of seismicity using extant structures of old date. It is usually considered rather improbable that early structures, liable to damage by earthquakes, could stand for many centuries in seismic regions. The mere fact that quite a few early monuments are still to be found in a state of tolerable preservation in various parts of the world, has led to the belief that these parts should be free from destructive earthquakes. (3) But historical and archaeological evidence shows that this is not the case. The early buildings that are still standing have in fact, during their lifetime, been subjected to a number of destructive earthquakes, and they have survived through a process of natural selection. They represent of course a very small fraction of the total number of structures that existed in early times, a sample of structures of the best final design and construction, achieved through the ages by trial-and-error techniques or by chance. For instance, frequent references occur in early literature to extensive repairs of walls, churches and other buildings on account of damage due to earthquakes, where the occasion was taken to introduce changes in the design and construction which produced a more resistant structure. Thus, the mere fact that a few early monuments are still standing in various sites in Greece, Turkey, Iran or even in Skopje and in Istanbul, should not be taken to mean that these sites have been free from damaging earthquakes, because this is unquestionably not so.

Perhaps it is one of our most interesting findings that the lasting effects of major earthquakes during the last 25 centuries would not seem to have been very significant. It was found that soon after a major earthquake vested interests invariably led people to act with a surprising disregard for such calamities. Yet, modern writers (4), (5) have attempted to use earthquakes to account for gaps in the sequence of civilizations and for movements of peoples, hypotheses for which we can find absolutely no historical justification. Earthquakes in the last 25 centuries have had little, if any, serious influence on historical developments in the Middle and Near East. They did quite often account for the premature decline of a local economy or for a crisis in local human affairs. Never have they caused, however, the ruin of a culturally advanced state, far less the end of a civilization. In contrast with wars, epidemics and other long-standing calamities which have serious and prolonged effects, earthquakes, no matter how large, seem to have had little long-term impact on man. It may be that men react to the inevitable hazard in a special way, distinct from preventable hazards. (2) Personal, political and economic interests seem to overshadow, and in some cases supress the lessons to be learnt from destructive earthquakes. For instance, villages ruined by early earthquakes are often rebuilt on different sites, whereas cities, where significant economic and political interests were involved, were rebuilt, enlarged and embellished, invariably on the same site, even when it was known that the site was unsuitable and that it had contributed to the disaster.

It is true that in some cases people attracted, perhaps by the ample budget usually available for repairs and reconstruction, have moved into earthquake stricken areas, causing a temporary influx of population. But it is also true that in the last 25 centuries, earthquakes have caused neither large-scale population movements, nor massive emmigration.

The work summarised in this note is part of a more general investigation into the early seismicity of the Near and Middle East supported by UNESCO.

REFERENCES

Ambraseys, N. (1962) "A note on the chronology of Willis' list of earthquakes in Palestine and Syria" Bull. Seism. Soc. Amer., Vol. 52, pp. 77-80.

Burton, I.; Kates, R. (1964) "The perception of natural hazards in resources and management" Natural Resources Journal, Vol. 3, No. 3, pp. 412-441

Frech, F. (1915) "Die armenischen Burgen" Zeitsch. Gesellsch. fur Erdkunde, Verlin, pp. 576-580.

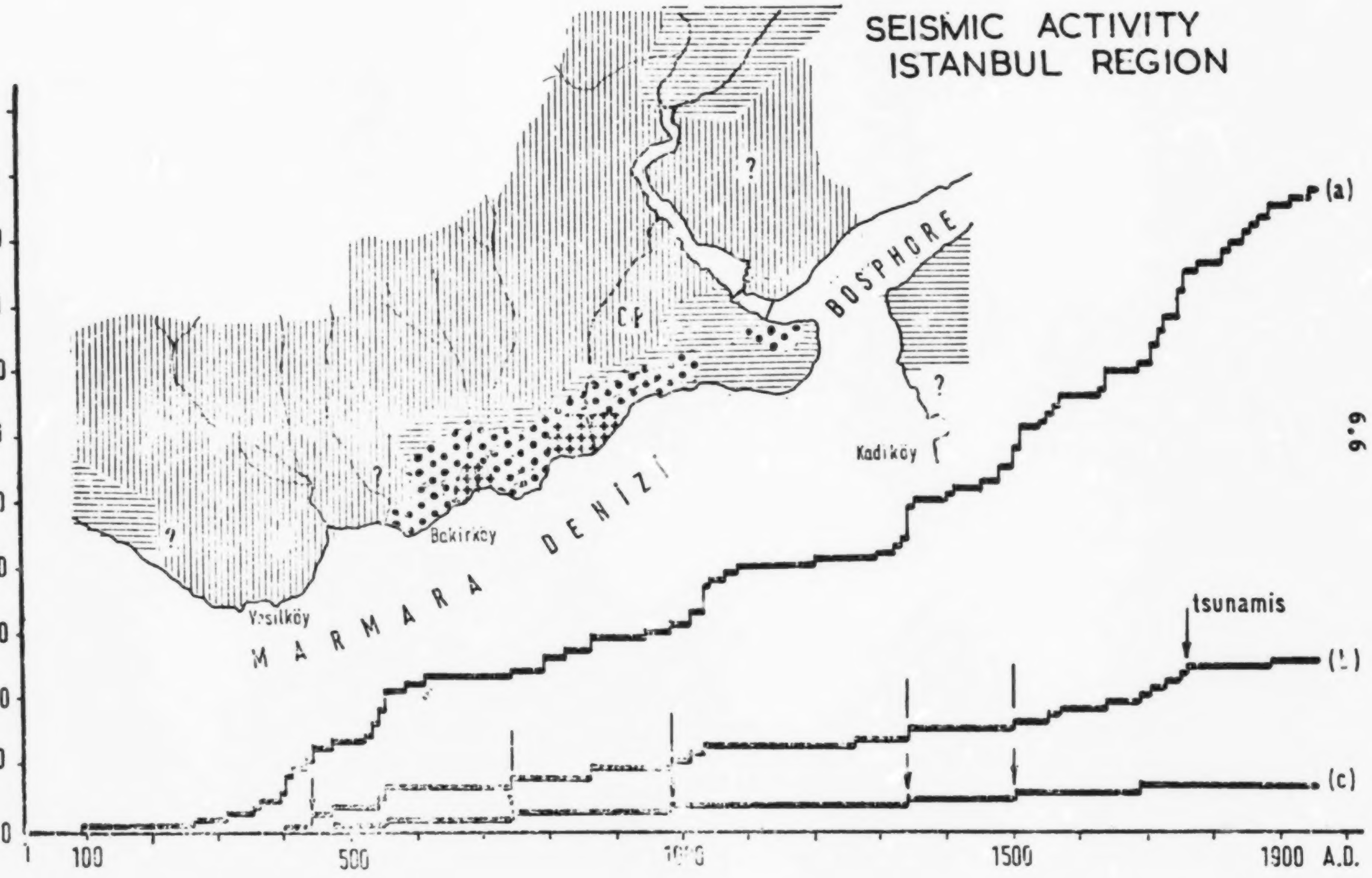
Marinatos, S. (1939) "The volcanic destruction of Minoan Crete" Antiquity, Vol. 13, No. 52, pp. 425-439.

Schaeffer, C. (1948) "Stratigraphie comparee et chronologique de l'Asie Occidentale," Oxford.

Sieberg, A. (1932) "Erdbebengeographie" in B. Gutenberg's Handbuch der Geophysik, Vol. 4, Berlin; also in Denkschriften der Medizin. Naturwissensch. gesellschaft zu Jena, Vol. 80, 1932.

N. N. Ambraseys
Engineering Seismology Section
Imperial College of Science
London S.W.7.

CCMS No. 9



SEISMIC ACTIVITY
ISTANBUL REGION

Earthquake Resistant Design NBC 1970

By

R. H. Ferahian

Nearly all the world's earthquakes occur in one or other of well defined seismic regions - the Circum Pacific Belt and the Alpide Belt. (Figure 1) The west coast of Canada forms a part of the Circum Pacific Belt. Within the past twenty-five years there have been two major earthquakes in British Columbia, one close in the state of Washington, and recently the Good Friday earthquake of Anchorage, Alaska. Figure 2 shows the epicentral map of Western Canada for the period 1900-1960 for earthquakes of magnitude greater than or equal to 5. Magnitude of an earthquake is the measure of its energy release and Magnitude 5 earthquake is usually taken as the threshold of damage. The epicentre of the earthquake is the point on the surface of the earth radially above the origin (focus) of the earthquake.

It is not only in British Columbia that we have earthquakes; the St. Lawrence and Ottawa River Valleys is the other though anamolous area of seismic activity in Canada. Earthquakes in this area have been reported ever since the voyages of Jacques Cartier (1534-35). (See Figure 3) There is also some evidence that the Indian tradition includes a large earthquake in the remote past. More recently there have been three major shocks in the St. Lawrence Valley within the lifetime of a good many of us present here. Fortunately, only two of the smallest of these earthquakes hit close to cities. The others were in farming districts or in even more sparsely inhabited areas where there was little or no damage. There is no doubt, however, about their potential danger; if any of our large earthquakes had hit under a large city, the results might have been disastrous. Figure 4 shows a comparison of the energy released by the major Canadian Earthquakes with some of disastrous world earthquakes, again emphasizing the damage potential of our earthquakes. (1)

Seismic Regionalization

There is no area in Canada that is immune to seismic activity, however the probability of occurrence of major earthquakes is largest on the West Coast and in the St. Lawrence and Ottawa River Valleys. Any scientific approach to earthquake resistant design must take earthquake probabilities into account when specifying the earthquake design forces. For this purpose seismic regionalization maps are prepared. One of the innovations in the 1970 issue of the National Building Code is the new seismic regionalization map of Canada which is based on the statistical seismicity analysis of the country supplemented where possible by tectonic information.

The Earthquake Probability map which appeared in the 1965 National Building Code (Figure 5) was based on John H. Hodgson's visual inspection of the epicentral data available at the time (1956). You have already seen what epicentral data maps look like. The limitations of this map were fully realized. The map was based on what was known about past earthquakes in Canada and adjacent areas and what geological data suggested about probable occurrences of earthquakes. Thus, the fact that earthquakes had occurred in Montana, immediately south of the border, suggested the possibility that they could happen in Alberta and southern British Columbia; the fact that earthquakes are found everywhere around the boundary of the Pacific would have insisted that British Columbia be regarded with suspicion even if there had been no known earthquakes in its coastal areas. The Canadian Shield regarded by geologists as a stable area was placed in Zone 0; but recent occurrence of good-sized earthquakes have somehow dismayed the proponents of that belief. The engineers' resistance to this map's unnatural straight-line boundaries and the triple-point areas had good justification. However, the very general form of the boundaries was intended to imply that they were not well defined. At no time was it suggested that the map was in any sense final; it was simply the best that could be done at the time.

The recent completion of the catalogues (2)(3)(4) of Canadian earthquakes has enabled W. G. Milne and A. G. Davenport (5) to produce contours of ground seismic accelerations with a given annual probability of exceedance, based on a computer analysis of the past earthquakes throughout the country. The seismic data are handled as a statistical sample in the same manner as the maximum floods or snow loads are calculated, making use of the extreme-value theory of statistics. The sample used is for the period 1899-1963. The results for this sample are corroborated by those from a larger but less reliable sample dating back to 1638. Based on this study, it was found that for a city on the West Coast and in an area north of Quebec City the probabilities of earthquake occurrence are the highest in Canada and are generally comparable to the probabilities for similar sized city in California. (6) Montreal and Ottawa and their environs seem, by comparison with the Californian situation, to be less active seismically.

The design earthquake chosen for zoning purposes is the "100-year" earthquake, i.e. an earthquake with an annual probability of exceedance of 1 in 100. The ground acceleration corresponding to this earthquake is A_{100}. The reasons behind this choice are given elsewhere (6). The zone boundaries in terms of A_{100} as shown in Table 2 have been used in the preparation of the new seismic regionalization map of Canada and in the evaluation of the seismic regionalization factor R, (6) appearing in Supplement No. 3 of the NBC. (Figure 6). Table 1 shows a comparison of the seismic regionalization factor R as given by NBC 1965 and 1970. The ratios of the base shears as given by NBC 1965 and 1970 are not direct ratios of the R factor because there are other differences between the codes as will be explained later on.

The Base Shear

For a given earthquake, the response elastic base shear V_e for a single mass spring system (e.g. symmetrical single storey industrial structure) has the form

$$V_e = \frac{W}{g} S(t,T,\eta,\ddot{x})$$

where W is the Weight of the System
g is the acceleration of gravity
$\ddot{x}$ is the ground acceleration
T is the natural period of vibration of the system
η is the percentage of critical damping
$S(t,T,\eta,\ddot{x})$ is a function of time, t, the applied earthquake $\ddot{x}$ (i.e. its acceleration and frequency content and duration which are in turn function of the soil and site properties), the natural period of the structure T, and its damping characteristics η.

Thus for a given structure of period T, S and hence V_e are dependent on the character of the ground acceleration and the damping available in the structural system. The maximum value of V_e corresponds to the maximum value of S denoted by S_a. The plot of S_a for a given earthquake as a function of period and damping is shown on Figure 7. These curves are extremely important to the engineer and they are called acceleration spectra (8). The average acceleration spectra for the few available strong motion Californian earthquakes are used as a basis for the design. These average spectra are naturally smoother than those on the last slide. They show a peak in the period range 0.2 - 0.5 and decrease for the higher periods.

Structures could be designed to resist catastrophic earthquakes elastically; this however, would be prohibitively expensive and unwarranted for the small probabilities of occurrence of such catastrophic earthquakes. Instead, the design objective is to render most of the structures capable of resisting major catastrophic earthquakes by marshalling its energy absorptive capacity in the post elastic stage of structural behavior. For a steel structure this would mean that vibration energy is expended by plastic action in few members and joints.

Analysis of the non-linear earthquake response of elasto-plastic one-mass structures have demonstrated that the displacements to be expected in a yielding system are about the same as if the structure had remained fully elastic (9). (Figure 8) The amount of permissible yielding developed during the response is expressed most conveniently in terms of the ductility factor μ, which reflects the energy absorptive capacity of the structure. The ductility factor may be defined as the ratio of the elastic plus permissible plastic displacement to the initial yield displacement. If the maximum displacement of the elasto-plastic system is the same as the maximum displacement of the corresponding fully elastic system, then the design base shear V is given by:

$$V = V_e/\mu\lambda = W\,S_a/\mu\lambda$$

where S_a is the spectral acceleration as a percent of gravity and λ is the ratio of the yield stress to 1.33 times the allowable stress for the material of construction of the structural system. The factor 1.33 accounts for the 33% allowable increase of the allowable stresses under the condition of earthquake loads combined with dead and live loads. Typical ductility factors might range from three to five in these analyses.

It is clear therefore that the greater the ductility or energy absorptive capacity of the structure, the smaller is the design base shear force. This is extremely important deduction to keep in mind.

Further analyses have shown that similar base shear force relationships apply with reasonable accuracy to multi-storey buildings having many modes of vibration. For usual structures of moderate heights (up to 20 or 30 storeys) the principal earthquake response is associated with the fundamental mode of vibration, and the base shear is dependent primarily on the period of this mode.

Minimum Earthquake Base Shear (NBC 1970)

The National Building Code (1970) specifies that the structure shall be designed for a minimum earthquake force applied in any horizontal direction given by

$$V = \frac{1}{4}.R.I.F.C.K.W$$

It is clearly seen that the form of this equation is similar to the one given earlier. The coefficients are defined as follows:

R is the Seismic Regionalization Factor, as explained earlier. It is equal to 4, 2, 1, or 0.

I is the Importance factor for the structure defined as in NBC 1965. It is equal to 1.3 for post disaster service building and schools (new in NBC 1970) otherwise it is equal to 1.

F is the Foundation factor as defined in NBC 1965. It is equal to 1.5 for structures founded on highly compressible soils otherwise it is 1.

The foundation factor F only crudely accounts for the influence of the site conditions on the earthquake forces. It does not account for the possibility of ground failure beneath the structure due to land slides as those that occurred in Anchorage, Alaska (10) or due to earth consolidation or liquefaction of sands in areas of high water table and loose, medium dense, cohesionless soils as those that occurred in Niignta, Japan (11). For such cases, an experienced soils engineer should be consulted for the evaluation of the suitability of the site and the nature of its behavior under the anticipated seismic forces and movements.

C is given by $\frac{0.05}{\sqrt[3]{T}}$ where T is the period of the structure. C shall not be taken greater than 0.1. Except where properly substantiated technical data are submitted, T shall be determined by one of the following formulae.

$$T = 0.05 \frac{\text{Height}}{\sqrt{\text{Depth}}} \quad \text{or } T = 0.1\ N$$

where N is the total number of storeys above exterior grade. The latter equation applies to buildings incorporating moment resisting space frame capable of carrying all the required lateral forces.

C is meant to account for the variation of the earthquake Response Spectra as a function of the period. It replaces the factor S of NBC 1965. One of the improvements of the NBC 1970 is the introduction of this parameter C as a function of the period. In this form the base shear reflects theory more closely and does give the expert the chance of improving his estimate by better estimate of the period. The equations for C and T are the same as those appearing in the Uniform Building Code (13) and the SEAOC Code (13).

K - The coefficients K assigned to different types of structural system are given in Table 4.1.7.A reproduced out of NBC 1970. They replace the C factor of NBC 1965 which was either 0.75 or 1.25. These K factors have been chosen based on experience in design and construction, as well as analysis for the evaluation of the performance of the structures under major and moderate earthquakes in California and Alaska. They endeavor basically to account for the energy absorptive capacity of the structural system by damping and inelastic action. As explained earlier when introducing the ductility factor, types of construction that are recognized to have performed well in earthquakes are assigned lower values of K than those that have not. K varies between 0.67 and 3. Space frames with moment resisting connections designed to resist all the lateral forces in a ductile manner are known to have the highest ductility or energy absorptive capacity thus they have been assigned the lowest value of K. The value of K equal to 3 for elevated water tanks as described in the table accounts not only for the ductility but also for the extra safety needed in their design because they are needed in the possible fire fighting subsequent to the earthquakes. A detailed explanation on the choice of the coefficient K is given elsewhere. (6)

Let us take a few examples for buildings which are neither schools nor those designed for post disaster services, that is I is equal to 1. Consider these buildings to be in Zone 3 (R = 4.) and not founded on highly compressible soils (i.e. F = 1.). Then

$$V = CKW.$$

Let us simplify the problem even further by assuming C = 0.1,

$$\therefore V = 0.1\ KW.$$

Now if the structure is a ductile (e.g. steel) space frame designed to carry by moment resistive connections all the lateral loads then K = 0.67 and

$$V = 0.067\ W.$$

K = 0.67 can also be used for a reinforced concrete space frame if it is specially detailed to incorporate adequate ductility (6)(13)(14).

If the structure is reinforced concrete space frame e.g. flat slab then K = 1 and

$$V = 0.10\ W.$$

If the structure is composed of a mixture of shear walls and partial frames then K = 1.33 and

$$V = 0.133\ W.$$

Now let us consider a 20 storey building. If it is designed for K = 0.67 then T = 0.1(20) = 2 sec. and

$$C = \frac{0.05}{\sqrt[3]{2}} = 0.04$$

$$V = 0.67(0.04) = 0.027\ W.$$

If the same building incorporated a structure composed of a combination of plane frame (incomplete space frames) and shear walls then K = 1.33, and if the period as calculated from

$$T = 0.05\ \frac{\text{Height}}{\sqrt{\text{Depth}}} \text{ is } 1.5 \text{ sec.}$$

Then

$$C = \frac{0.05}{\sqrt[3]{1.5}} = 0.044$$

$$V = 0.044(1.33)\ W = 0.058\ W.$$

Shear Force Distribution

Having estimated the base shear then this force is distributed up the building as done in the NBC 1965 with one difference - a portion F_t of the base shear V not exceeding 15% shall be concentrated at the top of the structure. The force distributed will be $V - F_t$. The allocation of this force F_t to the top of the structure is to account for the effect of the higher modes of vibration of the structure.

The Overturning Moments

NBC 1965 did not allow reduction of the overturning moments. NBC 1970 allows this by multiplying the calculated overturning moments by a factor J which is a function of the period T. J is given by

$$J = 0.5 + 0.25/\sqrt[3]{T^2}$$

This is not as large as a factor as some of the Californian Codes (12)(13) allow (Figure 9). The choice of this conservative reduction factor has been prompted by the recent experiences in Anchorage and Caracas (10)(14). The introduction of this reduction factor endeavors to account for the fact that the components of the base shear contributed from the different modes of vibration do not have their maxima occurring all at the same time.

Torsional Provisions are almost the same as those given in the NBC 1965.

Attachments and Portions of Buildings are to be designed for a lateral force equal to 1/4 RC times the weight of the portion. The appropriate values of C_p are given in Table 4.1.7B reproduced herein. NBC 1965 lumped all attachments together providing the same design force for all of them. Naturally some attachments were designed unnecessarily safe at the expense of others. The purpose of the Table 4.1.7B of NBC 1970 is to rectify this. For example in Zone 3 (R=4), NBC 1970 specifies C_p of 1.0 for cantilever parapet walls and 0.2 for partitions; NBC 1965 would have specified 0.2 R i.e. 0.8 for both of them.

Masonry

Unreinforced masonry buildings have fared very badly when subjected to major earthquakes (10). In reinforced masonry structures, the presence of reinforcing will provide ductility and ensure against brittle failure. The Californian codes (12)(13) specify that all masonry elements within the structure shall be reinforced to withstand the earthquake forces. The National Building Code 1970 specifies now (not in NBC 1965) that all masonry in seismic Zones 3 and 2 (with few exceptions) shall be reinforced according to provisions of Section 4.4.3 of the Code. These elements include exterior bearing and non-bearing walls, parapet walls, interior bearing walls and partitions which weigh more than 40 p.s.f. or are more than 10 ft high. Masonry elements around stair and elevator shafts are required to be reinforced to ensure a safe means of egress from the structure. At present the National Building Code allows unreinforced masonry in Zone 2 if it can be proven to the satisfaction of the authority having jurisdiction that the plain masonry structure can withstand the design earthquake forces. Examples and Detail Sheets for the aseismic design of reinforced masonry can be found elsewhere (15).

At present, masonry structures designed according to Part 9 (Housing) of NBC 1970 need not be designed specifically for the earthquake forces given in Section 4.1. Buildings that may be designed under Part 9 (Housing) shall not be more than 3 storeys high or 6,000 square feet in floor area, and shall not be used for Assembly and Institutional occupancy.

Special Provisions

This is new in the National Building Code 1970. It specifies that except in zone zero for cases listed in the next paragraph, buildings higher than 200 ft shall have structural systems for which K is either 0.67 or 0.80. This reflects the Californian practice (12)(13) which specifies a height limit of 160 ft. Although this has been partly traditional, both analysis (16) and experience with earthquakes has shown that this is good practice.

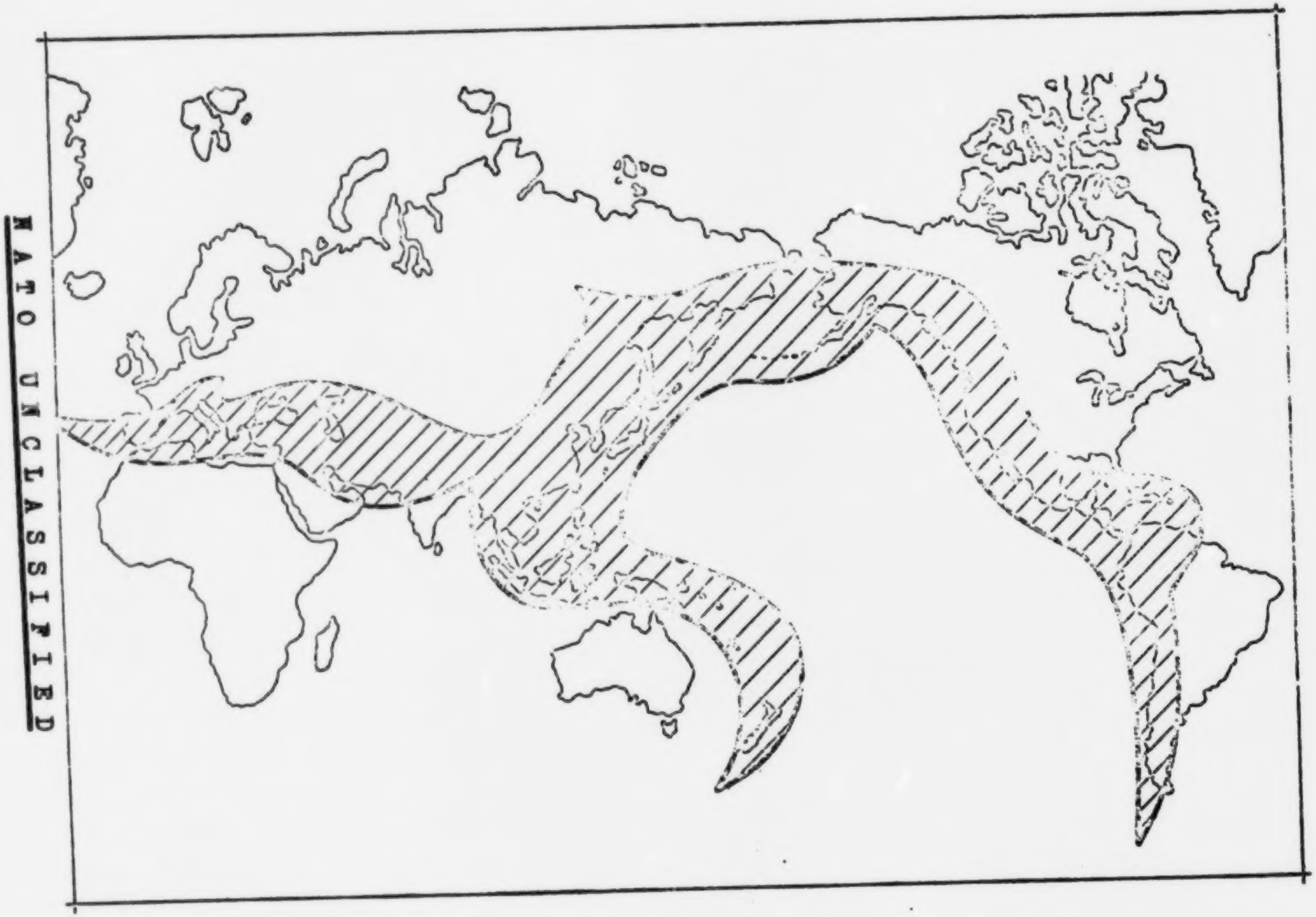
In order not to stifle innovation and impose unwarranted restrictions on earthquake engineering experts, the National Building Code 1970 allows approval of other structural systems by the authority having jurisdiction when evidence is provided that the proposed system can withstand the appropriate design earthquakes with ductility and energy absorptive capacity equivalent to that for structures with K = 0.67 and 0.8 (6). The National Building Code relaxes this requirement for seismic Zone 1 in that it allows building over 200 ft with shear walls carrying the total lateral forces in lieu of a ductile complete moment resisting space frame if the ductility of these walls is ensured by proper detailing. (6)(12)(13). Needless to say this relaxation of the rules without proof by dynamic analysis or otherwise is allowed because of the comparatively smaller seismic risk in zone 1.

Conclusions

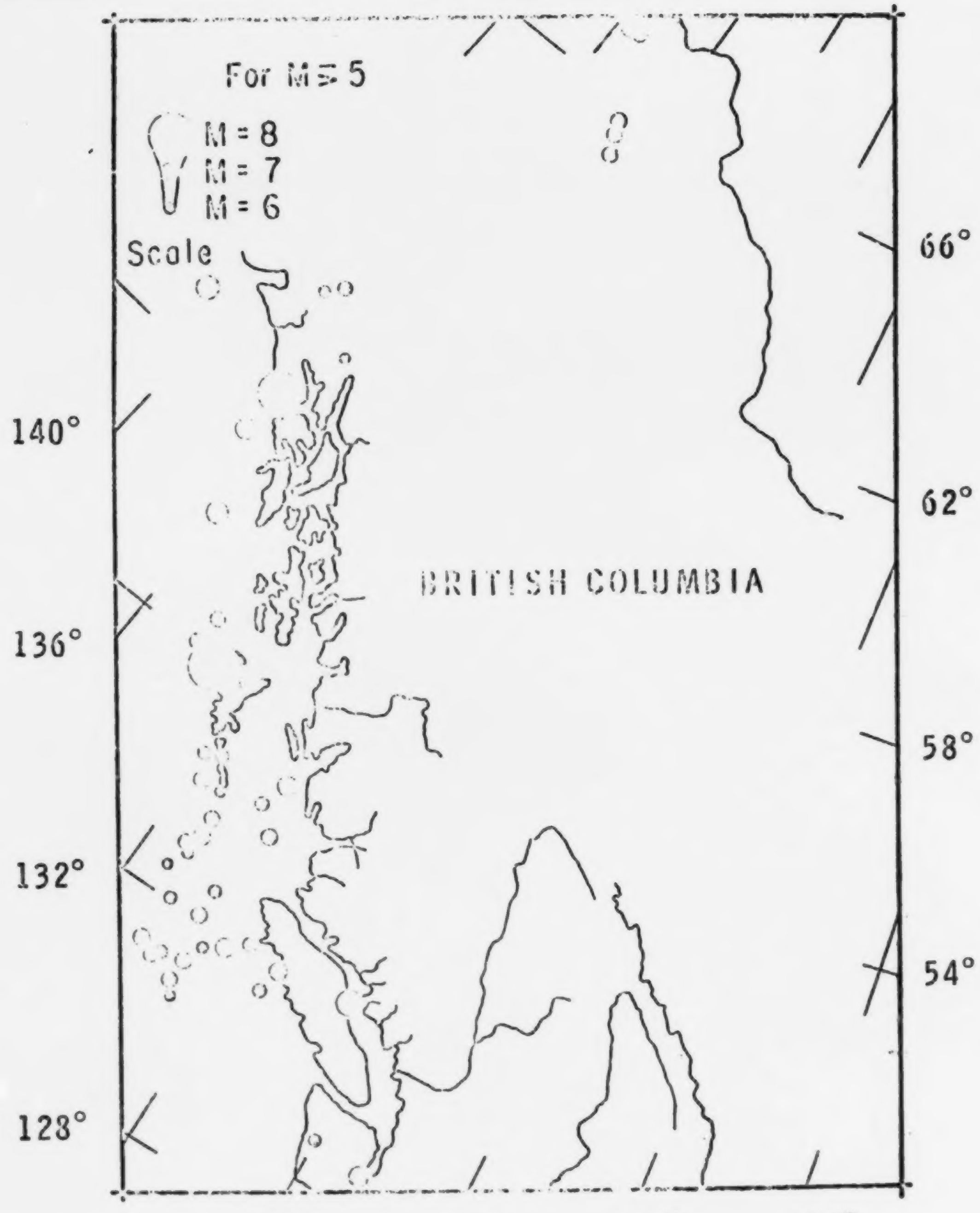
NBC 1970 is an uptodate living code. It has a most advanced seismic regionalization map which takes into account the seismic probability in the country dating back to 1534. A Commentary on loads due to earthquakes (6) is provided to assist the designers in the interpretation of the code and to provide the necessary supplementary information and references.

The earthquake resistant design requirements of the National Building Code provide minimum standards to assure public safety by safeguarding against major failure and loss of life. Structures designed in conformance with its provisions should be able to resist minor earthquakes without damage, resist moderate earthquakes with minor structural and some non-structural damage, resist major catastrophic earthquakes with probability of collapse small enough to be practically nil.

In most structures when designed according to the code with due attention paid to site and foundation selection, details of connections, and good material and construction control, it is expected that the structural damage due to the majority of earthquakes could be limited to repairable damage. It should be emphasized here that good detailing and the provision of energy absorptive capacity to enable the structure to withstand large deflection without collapse is most important. A structure designed for a small force but with excellent structural connections and details is far superior to one designed to withstand a larger force but with inferior details. It takes very little effort to initially plan the structure with its seismic behavior in mind with great subsequent savings in time and money.



THE CIRCUM-PACIFIC EARTHQUAKE BELT


For M≥5
M = 8
M = 7
M = 6
Scale
66°
62°
58°
54°
140°
136°
132°
128°
BRITISH COLUMBIA
24°
120°
116°
112°

EARTHQUAKES IN WESTERN CANADA, 1900-1960

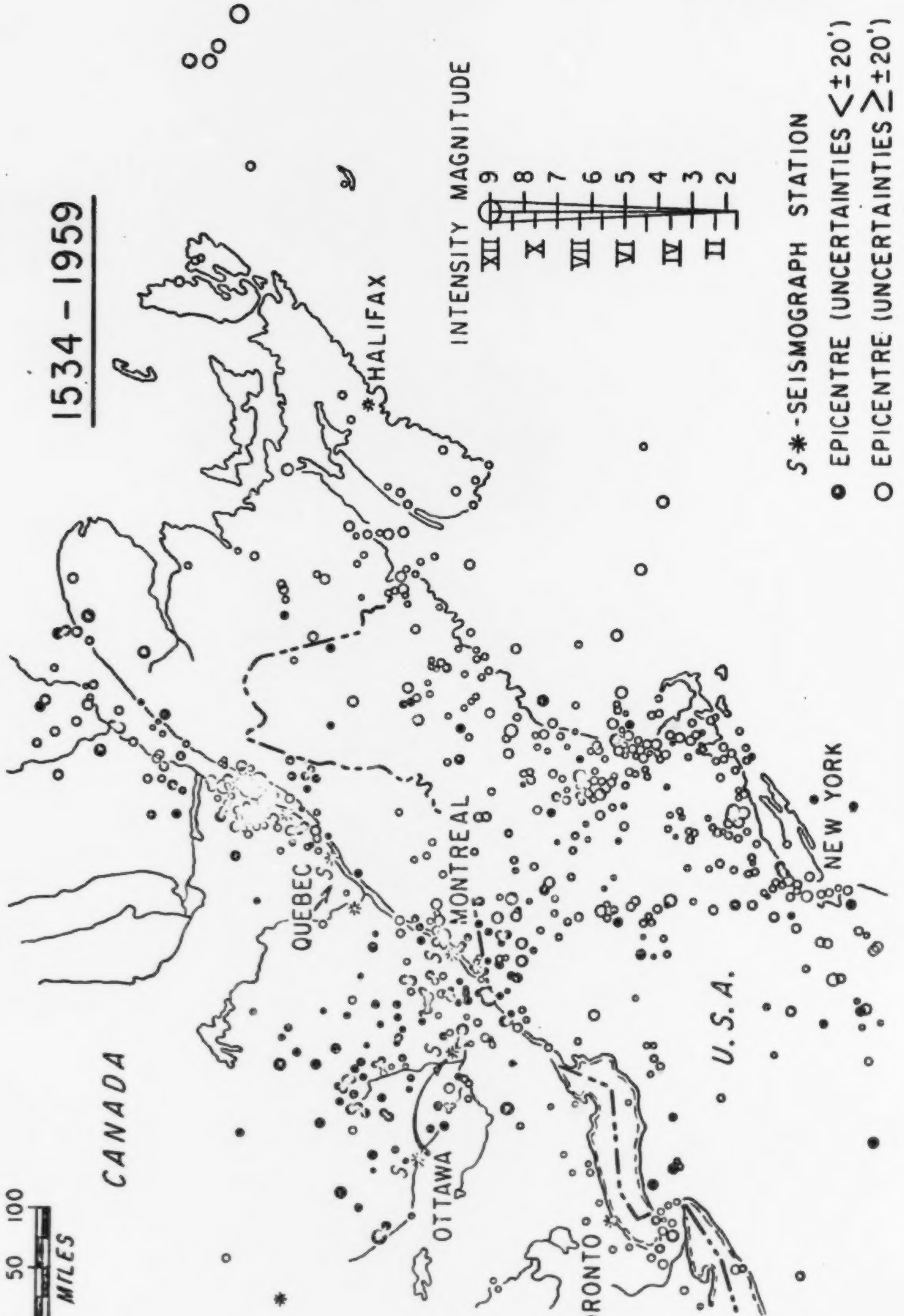
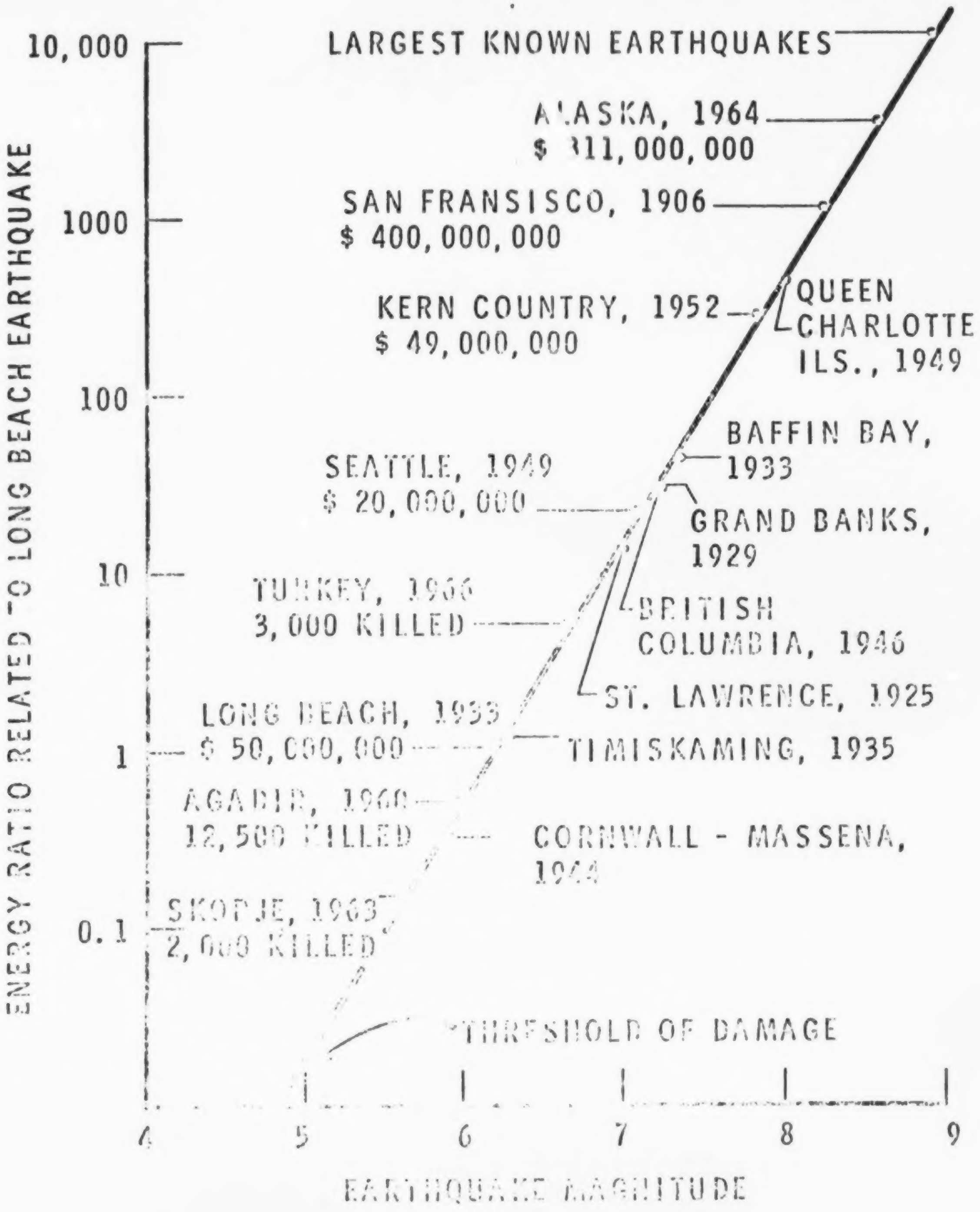

1534 - 1959
HALIFAX
INTENSITY MAGNITUDE
XII 9
X 8
VIII 7
VI 6
5
IV 4
3
II 2
S ✱ - SEISMOGRAPH STATION
● EPICENTRE (UNCERTAINTIES < ±20')
○ EPICENTRE (UNCERTAINTIES ≥ ±20')
CANADA
QUEBEC
MONTREAL
OTTAWA
TORONTO
U.S.A.
NEW YORK
0 50 100
MILES

FIGURE 3 EARTHQUAKES IN EASTERN CANADA

Reproduced from best available copy.



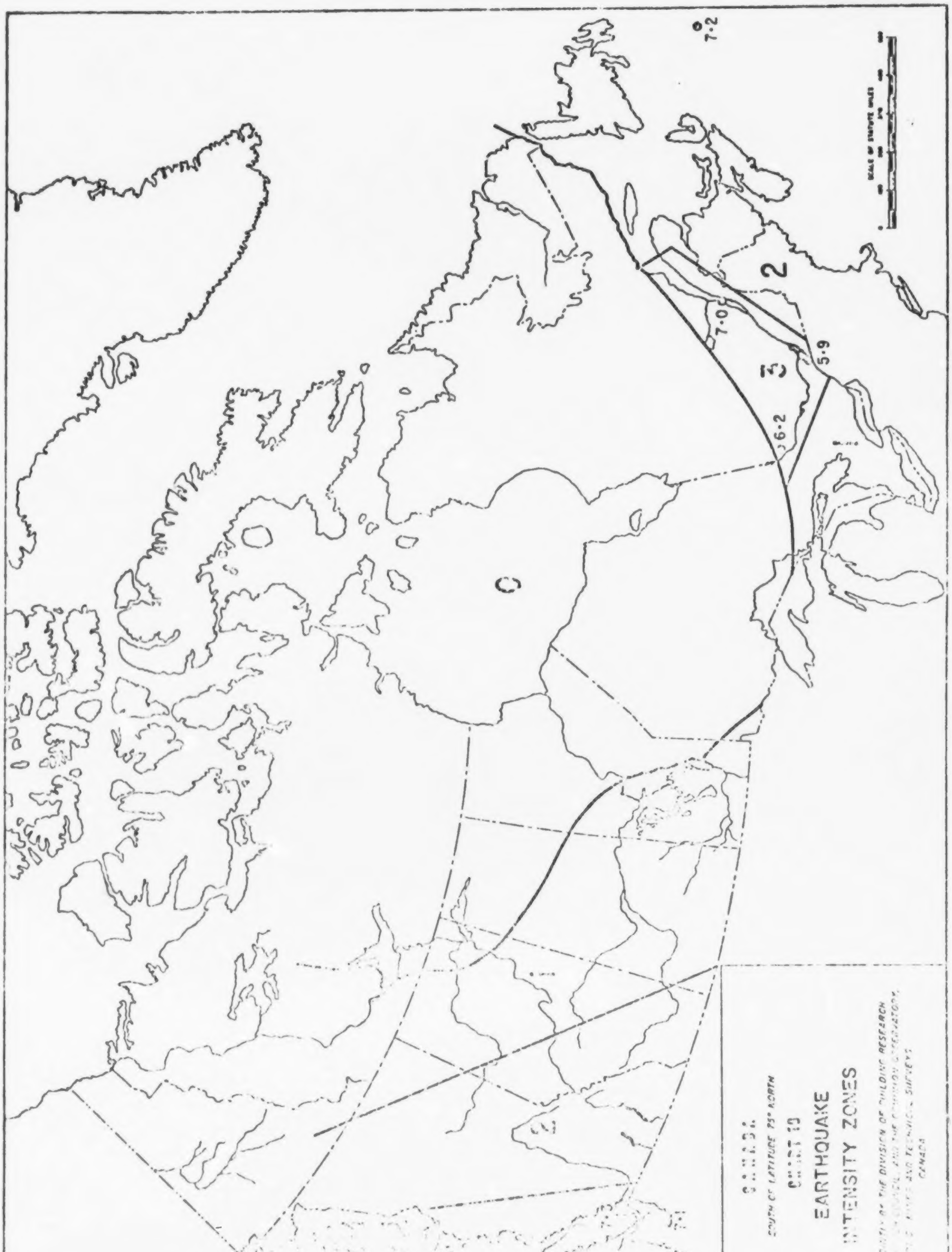

7·2
2
7·0
3
5·9
6·2
0
2
CANADA
SOUTH OF LATITUDE 75° NORTH
CHART 10
EARTHQUAKE
INTENSITY ZONES
PREPARED JOINTLY BY THE DIVISION OF BUILDING RESEARCH
AND THE DOMINION OBSERVATORY,
AND TECHNICAL SURVEYS
CANADA

FIGURE 5 EARTHQUAKE ZONING MAP OF CANADA NBC 1965

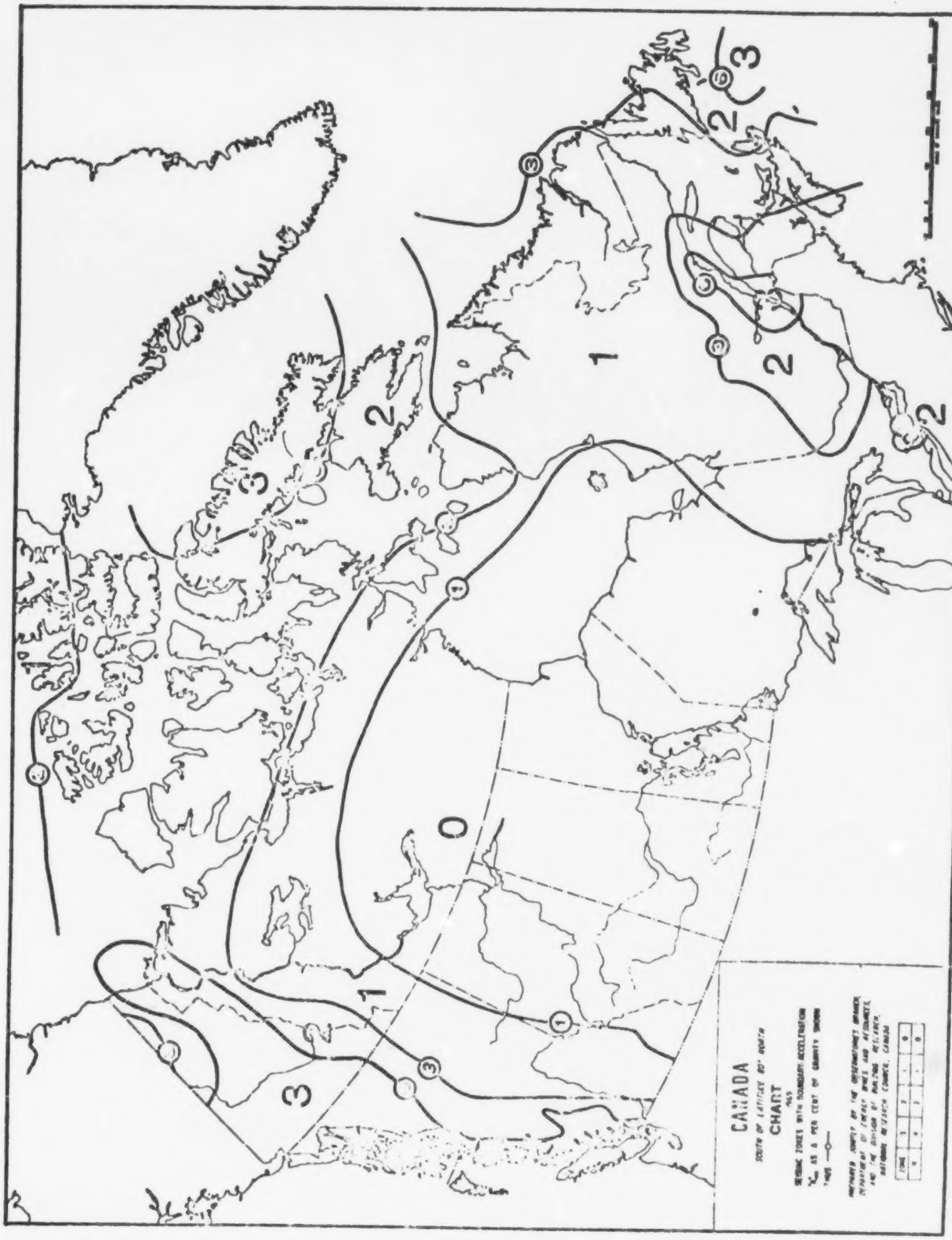

CANADA
CHART
0
1
2
3

FIGURE 6   SEISMIC REGIONALISATION MAP   NBC 1970

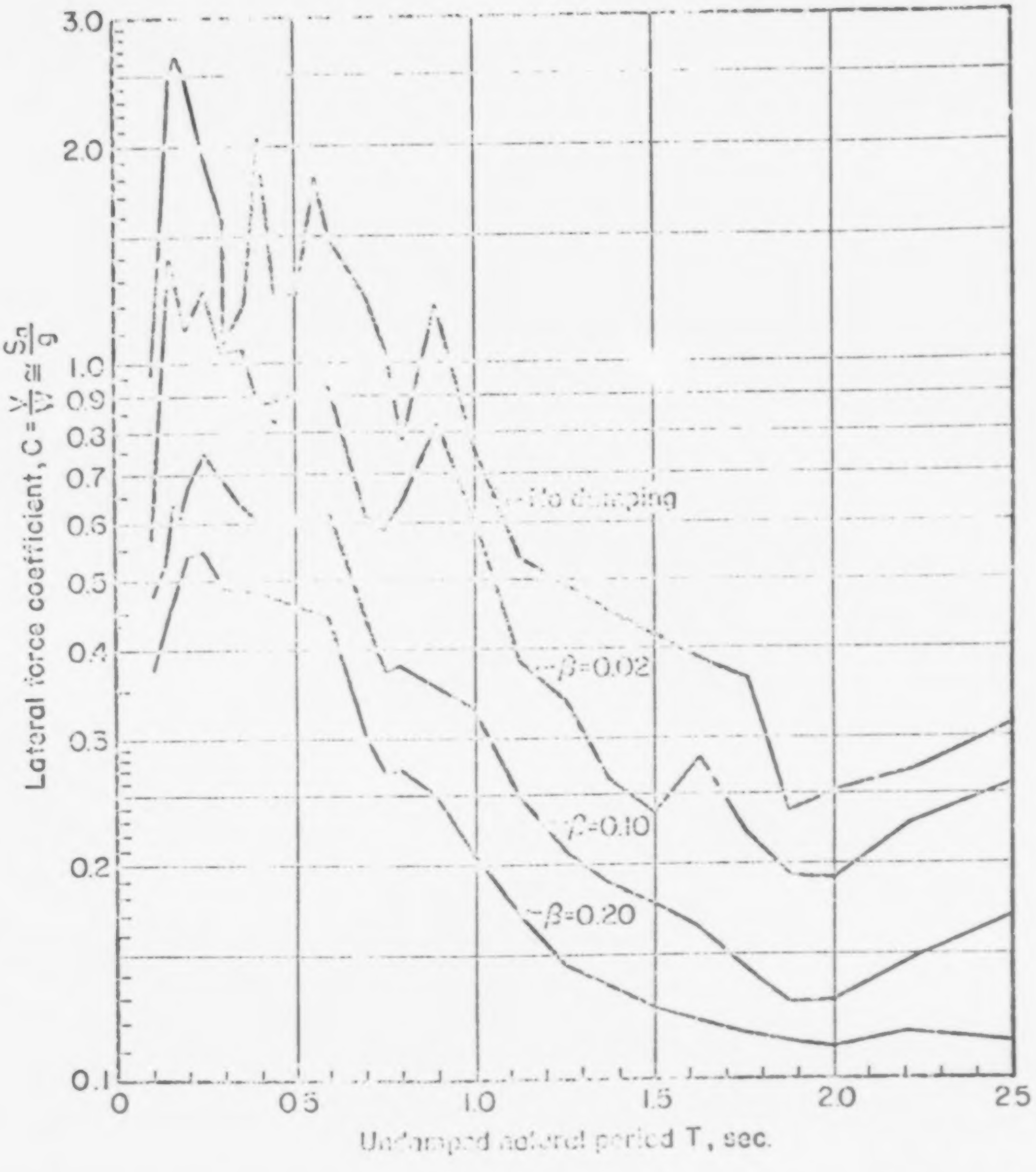


Fig. 1-5. Acceleration spectra for elastic systems, 1940 El Centro earthquake.

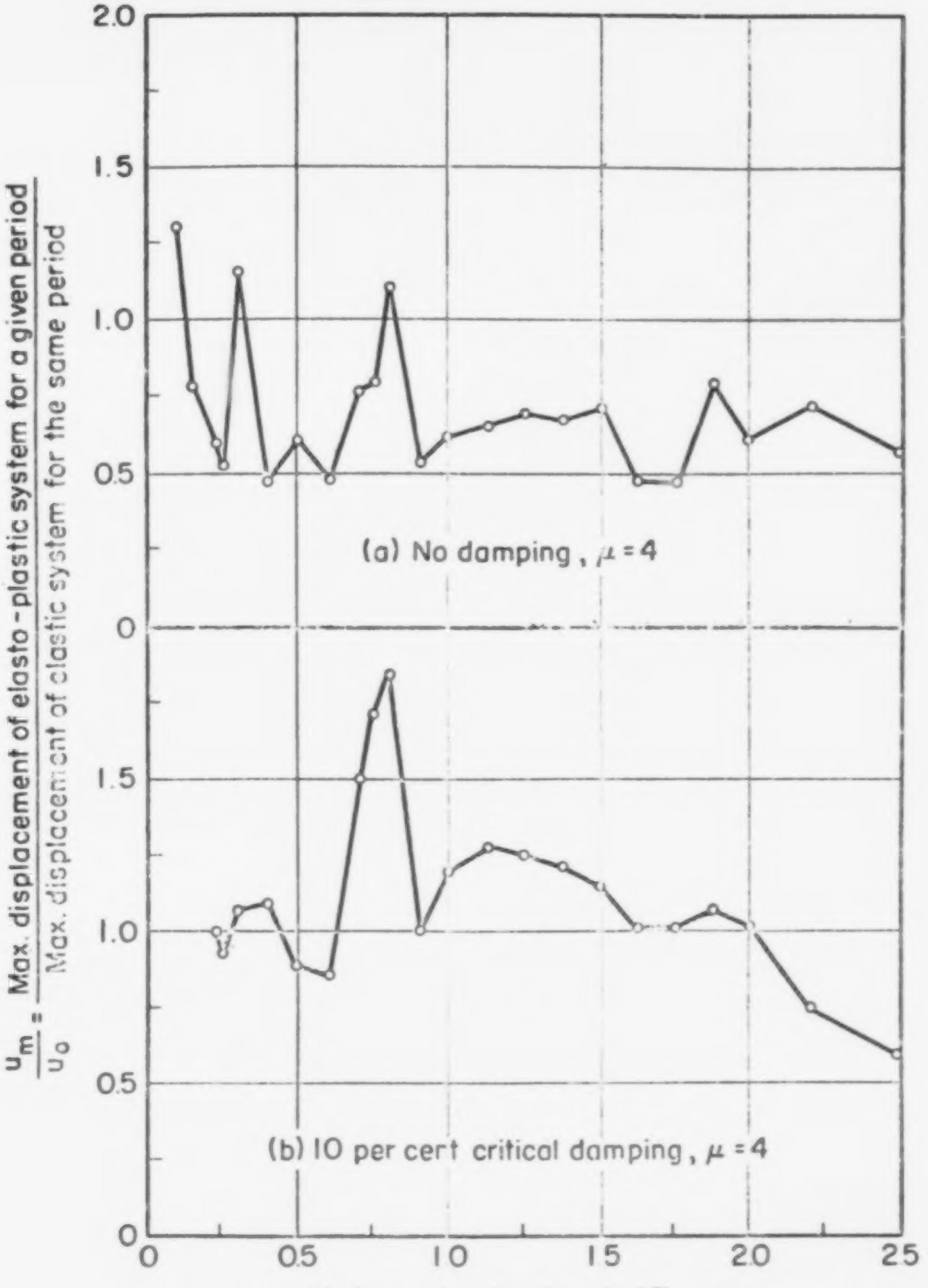


FIGURE 8

COMPARISON OF MAXIMUM RESPONSE OF ELASTO-PLASTIC AND ELASTIC SYSTEMS FOR 1940 EL-CENTRO EARTHQUAKE

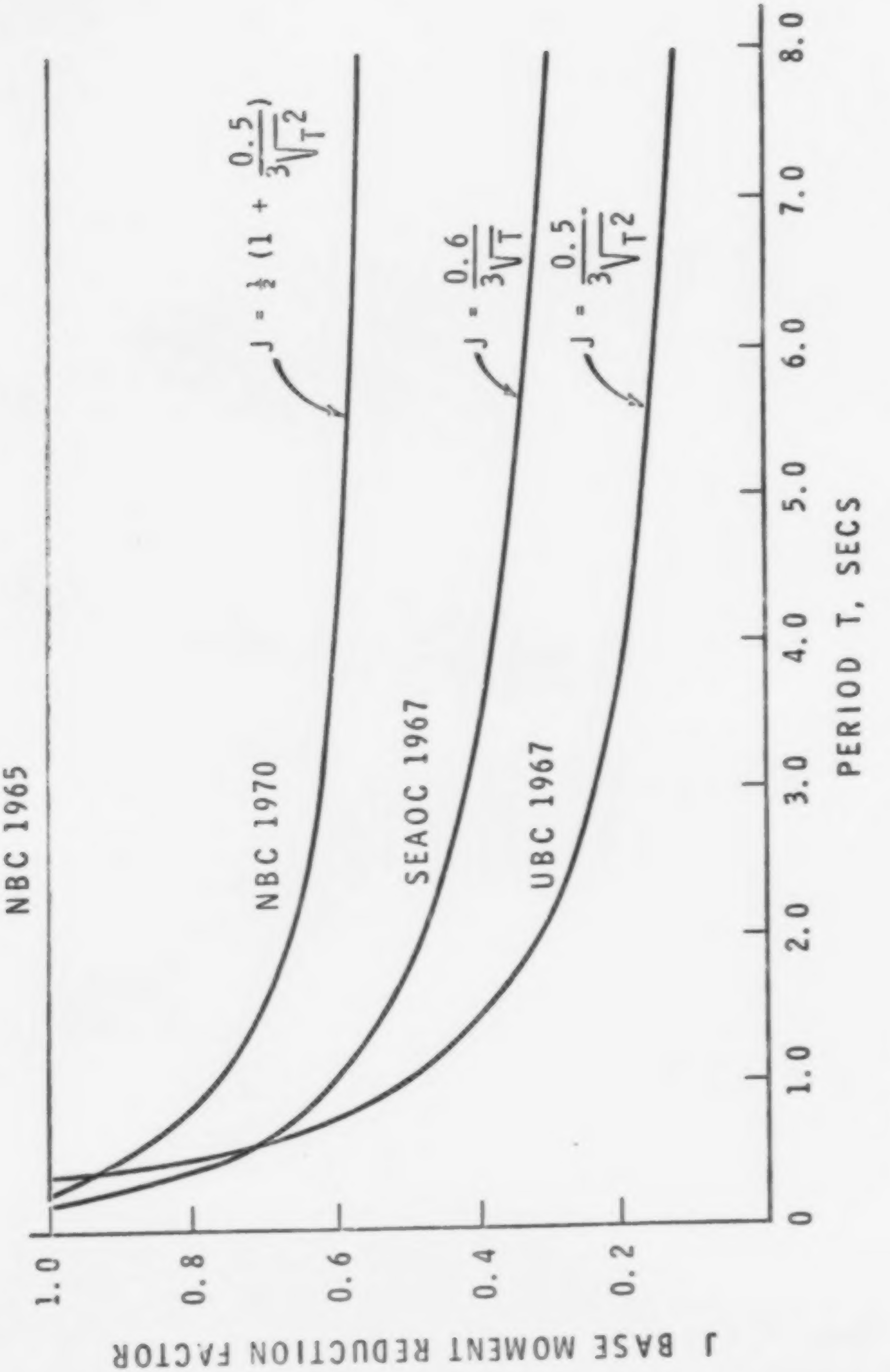


FIGURE 9
VARIATION OF THE MOMENT REDUCTION COEFFICIENT WITH PERIOD

TABLE 1. SEISMIC REGIONALIZATION FACTOR R

CITY	NBC 1965	NBC 1970
VANCOUVER	4	4
VICTORIA	4	4
CALGARY	2	0
EDMONTON	1	0
REGINA	1	0
WINNIPEG	1	0
TORONTO	1	1
HAMILTON	1	2
OTTAWA	4	2
MONTREAL	4	2
QUEBEC CITY	4	4
FREDERICTON	2	2
HALIFAX	2	1
ST. JOHN'S	2	1
CHARLOTTETOWN	2	1
WHITEHORSE	2	4
YELLOWKNIFE	0	0

TABLE 2 DEFINITION OF SEISMIC ZONES

Zone	Seismic Factor R	Range of A_{100} (Percent of Gravity)
3	4	$A_{100} \geqslant 6$
2	2	$6 > A_{100} \geqslant 3$
1	1	$3 > A_{100} \geqslant 1$
0	0	$1 > A_{100}$

Reproduced from best available copy.

Table 4.1.7.A.
Forming Part of Sentence 4.1.7.1.(4)

Type or Arrangement of Resisting Elements	Value of *K*
Buildings with a ductile moment resisting space frame (1), (2) with the capacity to resist the total required lateral force.	0.67
Buildings with a dual structural system consisting of a complete ductile moment resisting space frame and shear walls designed in accordance with the following three criteria: 1. The frames and shear walls shall resist the total lateral force in accordance with their relative rigidities considering the interaction of the shear walls and frames. 2. The shear walls acting independently of the ductile moment resisting space frame shall resist the total required lateral force. 3. The ductile moment resisting space frame shall have the capacity to resist not less than 25 per cent of the required lateral force.	0.80
All *building* framing systems except as hereinafter classified.	1.00
Buildings with a box system (3).	1.33
Structures other than *buildings* and other than those set forth in Table 4.1.7.B.	2.00
Elevated tanks plus full contents, on four or more cross-braced legs and not supported by a *building* designed in accordance with the following three criteria: 1. The minimum and maximum value of the product *KCI* shall be taken as 0.12 and 0.25 respectively. 2. For overturning the factor *J* as set forth in Clause 4.1.7.1.(7)(a) shall be 1.0. 3. The torsional requirements of Sentence 4.1.7.1.(8) shall apply.	3.00

Notes to Table 4.1.7.A.:

(1) A space frame is a three-dimensional structural system composed of interconnected members laterally supported so as to function as a complete self-contained unit with or without horizontal diaphragms.

(2) A ductile moment-resisting space frame is a space frame that is designed to resist all the specified seismic forces and that, in addition, has adequate ductility or energy-absorptive capacity.

(Information on ductile moment-resisting space frames can be found in the chapter on loads due to earthquakes in NBC Supplement No. 4, Canadian Structural Design Manual, 1970.)

(3) A box system is a structural system without a complete vertical load-carrying space frame.

Table 4.1.7.B.

Forming Part of Sentence 4.1.7.1.(6)

Category	Part or Portion of *Buildings*	Direction of Force	Value of C_p
1	All exterior and interior walls, except those of category 2 and 3	Normal to flat surface	0.20
2	Cantilever parapet and other cantilever walls except retaining walls	Normal to flat surface	1.00
3	Exterior and interior ornamentations and appendages	Any direction	1.00
4	Towers, tanks plus contents, *chimneys*, smokestacks, and penthouses — all when connected to or forming part of a *building*	Any direction	0.20(1)
5	Tank plus contents when resting on the ground	Any direction	0.10
6	Floors and roofs acting as diaphragms(2)	Any direction	0.10
7	Connections for exterior and interior walls and elements except those forming part of the main structural system as defined in Table 4.1.7.A.	Any direction	2.00

Notes to Table 4.1.7.B.:

(1) When *hn/D* of any building is equal to or greater than 5 to 1, increase value by 50 per cent.

(2) Floors and roofs acting as diaphragms shall be designed for a minimum force corresponding to the value of *Cp* of 10 per cent applied to loads tributary from that storey unless a greater force *Fx* is assigned to the level under consideration as per Clause 4.1.7.1.(5) (a).

BIBLIOGRAPHY

(1) J. H. Hodgson, "There are Earthquake Risks in Canada", Canadian Consulting Engineer, July 1965, Vol. 7, No. 7, NRC 8546.

(2) W. E. T. Smith, "Earthquakes of Eastern Canada and Adjacent Areas, 1534-1927". Publications of the Dominion Observatory, Ottawa, Vol. 26, No. 5, 1962.

(3) W. E. T. Smith, "Earthquakes of Eastern Canada and Adjacent Areas, 1928-1959". Publications of the Dominion Observatory, Ottawa, Vol. 32, No.3, 1966.

(4) W. A. Milne and K. A. Lucas, "Seismic Activity in Western Canada 1955 to 1959 Inclusive". Publications of the Dominion Observatory, Ottawa, Vol. 26, No. 1, 1961.

(5) W. G. Milne and A. G. Davenport, "Distribution of Earthquake Risk in Canada", 4th World Conference on Earthquake Engineering, Santiago, Chile, January 1969. Also Bulletin of the Seismological Society of America, Vol. 59, No. 2, pp. 729-754, April 1969.

(6) R. H. Ferahian, "Commentary on Loads due to Earthquakes", Chapter 3, Supplement No. 3 to the National Building Code (1970).

(7) G. W. Housner, "Behavior of Structures During Earthquakes", Journal of the Engineering Mechanics Division, ASCE, October 1959.

(8) G. W. Housner, et al, "Spectrum Analysis of Strong Motion Earthquakes", Bulletin of Seismological Society of America, Vol. 43, 1953.

(9) J. A. Blume et al, "Design of Multistory Reinforced Concrete Buildings for Earthquake Motions", Portland Cement Association, 1961.

(10) The Prince William Sound, Alaska, Earthquake of 1964 and Aftershocks, Vol. II, Research Studies, Seismology and Marine Geology, U.S. Department of Commerce, U.S. Environmental Science Services Administration, U.S. Coast and Geodetic Survey, U.S. Government Printing Office, Washington, 1967.

(11) The Niignta Earthquake, 16 June 1964, and Resulting Damage to Reinforced Concrete Buildings, International Institute of Seismology and Earthquake Engineering, Tokyo, Japan, February 1965.

Uniform Building Code Vol. 1, 1967 Edition, International Conference of Building Officials, Pasadena, California

(13) Recommended Lateral Force Requirements and Commentary, Seismology Committee, Structural Engineers Association of California, 1967.

(14) M. A. Sozen, et al, "Engineering Report on the Caracas Earthquake of 29 July 1967", National Academy of Sciences Washington, D. C. 1968.

(15) "Seismic Design for Buildings", Department of Army Technical Manual TM5-809-10, Washington, D. C., March 1966. Plate 2-16, Page 2-62.

(16) R. W. Clough and K. Lee Benuska, "FHA Study of Seismic Design Criteria for High Rise Buildings". A report prepared for the Technical Studies Program of the Federal Housing Administration, HUD TS-3 August, 1966.

EARTHQUAKE ZONING IN CANADA

by W.G. Milne(1)

Abstract.

Methods for obtaining an estimate of the earthquake risk in Canada are reviewed. Plots of epicentres are shown. The contour maps of strain energy release show that the Pacific coast and the St. Lawrence valley are in earthquake belts. b values for each of these regions are provided. The return periods for accelerations of 10% gravity are computed for the two regions. The extreme value method for calculating the acceleration with a 100 year return period (A100) is used to prepare maps of seismicity. The new 1970 seismic zoning map is drawn from the latter computation.

---

(1) Full data may be obtained from -
Victoria Geophysical Observatory
Victoria, Canada.

Report on German Relief Operations in Disasters Abroad

1969/70

Survey of German Relief Operations

1.0 Sequence of disasters

Between September 1969 and July 1970, the Federal Government rendered effective assistance in five disasters abroad. They were all natural disasters of an unimaginable magnitude.

The first was the flood disaster in Tunisia in September/October 1969 which was followed at the end of October by the earthquake in Yugoslavia. The earthquake in Turkey in March/April 1970 was followed by a flood disaster in Romania at the beginning of May 1970, and before the relief operations for Romania had been concluded, Peru was struck by an earthquake on 31 May 1970.

2.0 Causes and consequences

The damage caused by earthquakes and flood disasters showed similar criteria in all cases: concentrated destruction of towns and villages, isolation from the outside world, complete or partial destruction of supply networks, lack of communications, uninhabitable houses, many deaths and casualties. The building methods used in the countries concerned, which disregard the threat of disasters, had helped to increase the extend of damage. A fatalistic mentality (in non-European countries) and the effect of shock made people hardly able to help themselves. They were taxed beyond their material and physical resources. Even a highly civilized country in a similar situation would have had to draw on outside assistance, which is most effective when given quickly and in different forms depending on the type of damage.

3.0 Nature of assistance

The Federal Government provided goods and services in all cases. The goods comprised drugs and medicines, food, clothing, furniture and equipment, building materials, etc. The services were provided by relief teams with special technical equipment. Principal activities were:

- Preparation of drinking water (German Red Cross (DRK), Technical Relief Organization (THW))
- Erection of emergency shelters (DRK, THW, German Volunteer Service (DED))
- Bridge construction (THW)
- Setting up of field hospital (THW)
- Running field hospital (Maltese Order Relief Service (MRD))
- Installation and operation of radio equipment (DED, THW)
- Recovery of dead (THW)
- Removal of debris (THW)
- Mass feeding (MHD, THW)
- Distribution of auxiliary goods (MHD, THW)
- Medical care for helpers (THW, MHD, St. John's Accident Service (JUH)).

Goods and services were provided either as emergency measures (humanitarian phase) or in aid of reconstruction (reconstruction phase), as indicated by their sequence. The Federal Government's assistance always covered both phases, though naturally with greater emphasis on emergency measures.

4.0 Commencement and duration of relief operations

Measures for the humanitarian phase were started not long after the beginning of disasters, as soon as the offer of assistance or the request for help had been accepted.

On the instructions of the Federal Ministry of the Interior, where an emergency committee co-ordinated measures by Federal departments and relief organizations the Federal Civil Defence Agency formed an operations committee which was in readiness day and night.

The emergency measures of the humanitarian phase were started two to ten days after the disaster and lasted for two to five weeks. The provision of personnel and auxiliary goods was the task of the operations committee. Auxiliary goods were taken out of civil defence stores or purchased through the Federal procurement authority. All operations of the humanitarian phase were made particularly urgent. There was never much time for planning, preparation and organization.

The reconsctruction phase left more scope for preparations. It started in most cases 5 to 6 weeks after the start of the disaster. Typical projects of that phase are the construction of prefabricated houses stationary hospitals and bridges, including the supply of materials and assignment of expert personnel for advisory services.

5.0 Areas in which relief operations took place

Climate and geography in relief areas are sometimes quite different from those in Europe. In South America (Peru), at 8-12° Southern Latitude, relief operations are a greater strain on personnel and equipment than they would be in Europe. New criteria will have to be worked out regarding the technical equipment, relief workers' outfit and the suitability of helpers.

In some cases the teams provided the Technical Relief Organization and other organizations concentrated on certain areas or places. Concentrated operations are easier to direct than measures in decentralized areas. Scattered relief areas, such as in Tunisia and Peru, require a broader base for supplies, operational and transport means, and more than one person to direct operations.

A STUDY OF THE 28TH MARCH, 1970 EARTHQUAKE IN GEDIZ (TURKEY) WITH EMPHASIS ON THE BEHAVIOUR OF THE REINFORCED CONCRETE AND MASONRY STRUCTURES

by Dr. E. Karaesmen
Middle East Technical University, Ankara

1. INTRODUCTION

The earthquake on 28th March, 1970 which occured at 21 02 28.5 (GMT) according to the Geophysical Institute of Istanbul Technical University caused loss of life and severe damage on an area of 1,000 square kilometers (390 square miles) around Gediz. 1,086 people lost their lives and 1,265 people injured, almost all buildings were affected from this earthquake of estimated average magnitude of 7.2. More than 14,850 buildings were heavily damaged beyond repair or destroyed.

The main destruction zone covered the small towns of Gediz and Emet in the province of Kütahya, located approximately at 260 kilometers (160 miles) south-west of Ankara.

Immediately after the earthquake the inhabitants of the damaged areas were settled in provisiony dwellings or tents provided by the Ministry of Reconstruction and Resettlement and by the Red Crescent (Turkish Red-Cross). Later on, the foreign aids arrived from different countries and sources which were useful, indeed.

To resettle the people of the area, several new villages were constructed. About 7,000 inhabitants of the town Gediz, were completely resettled in a new town built at 6 kilometers south-west of the destructed town.

A symposium organized by the Turkish Society of Civil Engineers on Gediz Earthquake was held in Ankara, on June, 1970. The proceedings of this symposium are available now and a final summary report has also been prepared by the author. This study presented here is referred to this report.

2. ACTIVE TECTONICAL PROPERTIES OF TURKEY

Most of the seismic activity in the world is located, as known, along either "Circum-Pacific" or "Alpide" Earthquake Belts. "Circum-Pacific Belt" runs around the Pacific Ocean from New Zealand through Japan to the west coast of North and South Americas, whereas the "Alpide Belt" extends from Himalaya Mountains to Mediterranean Countries through Caucasus, Iran and Turkey. One of the most active faults on the "Alpide Belt" is the "North Anatolian Fault" running on the northern part of Turkey through Varto, Erzincan and Adapazari (Figure 1). The main part of this fault falls on the southern region of the Black Sea Mountain

Chain. The secondary faults extend down to Iranian Border in the East and to Marmara Sea in the West. The epicentres of the most violent earthquakes that occurred in this country are on or around this fault line. (30,000 people lost their lives in Erzincan, 1939; 260 people in Gonen, 1953; 2,300 people in Varto, 1966; also Akyazi-Mudurnu earthquakes 1967 and, etc.).

The second seismological characteristic of Turkey is the existence of the large neogene formations covering the Eastern part of Turkey. Some of the valleys of Eastern (or Aegean) Mountains coming perpendicularly to the Aegean Sea forms the tectonic grabens. These tectonic zones covered by neogene surfaces also often experienced heavy earthquakes, (Dikili 1949; Fethiye, 1955; Alasehir, 1968; etc.). On the map, (Figure 2) the neogene zones and the epicentres of the violent earthquakes that occurred in the Eastern Turkey since 1912 are shown.

For more detailed information the reader has to refer to the final reports published recently on the Akyazi-Mudurnu earthquakes (1) and also to the Proceedings of Gediz Earthquake Sympsium, held in Ankara, 1970 (2).

3. CHARACTERISTICS OF GEDIZ REGION

3.1 Geography

The total area of Turkey is 776,000 km2 (300,000 sq. miles) and its population is over 36,000,000 according to the 1970 population census.

Province of Kutahya covers in the middle western part of Turkey an area of 11,875 km2 (4,560 sq. miles) where a population of 420,000 live. The density of the population is 36 per km2 which is less than 47, the average density of the country. The rural population is about 75% of the total population of the region thus only 25% of the inhabitants live in the towns. The six of the small towns have a population over 2,000 and the southern town, Gediz is one of them, (Figure 3). The Gediz region looks like a high plateau of altitude 700 to 1,000 metres (2,300 to 3,260 feet). The land shows the laterally stratified and loosely cemented character of the neogene ages. The Gediz environment is divided by the "Gediz River" valley. The Saphane Mountains of height more than 2,100 metres (6,900 feet) run in the western parts.

Gediz is a snowy region. On the average, 35 days in a year, the soil is covered by the snow. The average temperature falls around 0°C (32°F) in February and 20°C (68°F) in July.

Agriculture is the basic economical activity of the Gediz region. Also more than 3,000 people work in the coal mines 15 kms (9 miles) east of Gediz.

3.2 Geology

The land formation around Gediz, if investigated from bottom to top shows various characteristics. (3) (Figure 4).

(A) Paleozoit aged Crystallin schists and marbles
(B) Neogenes aged sediments and igneous rocks
(C) Quarterner aged sediments

A. Crystallin schists and marbles:

Crystalline schists and marble deposits can be observed especially around the village of Yunuslar, which is to the North-east of the location considered and the plateaux of Seyrankasi and Arpayaylasi which lie between Gediz and Yunuslar. Micaxnist, quartzschist and calcschists are the governing elements of the latter. On the other hand around Akkaya, which is to the North of Gediz, massive marble blocks are observed. Although a proper strafication from bottom to top as given above is possible, a continuous section could not be observed, since they were covered with rigourus tectonic occurances and young neogenes formations.

B. Old neogenes sediments and igneous rocks:

Old neogenes sediments and igneous rocks observed in the region of Gediz, can be classified in five formations according to their different characteristics, from bottom to top:

(a) Asikpasa formation of thickness of 300 m
(b) Yayla formation of thickness of 300 m
(c) Yesilova formation of thickness of 250 m
(d) Akkaya formation of thickness of 350 m
(e) Altintas formation of thickness of 300 m

C. Quarterner aged sediments:

They consist of old river bed alluviums around Yunuslar, travertines of Degirmenkoy, Soguksu and Kayakoy, gypsum formations near Isiklar and also recent land slides constituents filling the valley of Gediz river.

The gypsum formation to the west of Isiklar is on the faulted contact zone between Yayla and Akkaya formations. The general appearance resembles that of a travertine formation, as a result of the reaction between sulpur dioxide gaseous-released due to fault formation and calcium bicarbonate solutions.

3.3 Seismological Characteristics of the Gediz Region:

Because of the tectonic graben, Gediz-Emet, formed on neogenes aged formations, the region had experienced several earthquakes in the past. A lot of neogenes originated fault lines are to be observed in the region. The most important land crack line is the line Dumlupinar-Gediz-Emet which has no continuity but a regular geometry on plan view.

Several hot water sources can be seen in the region, which might correspond also to tectonic activity of this portion of the land.

As for the detailed information about the seismicity of the region, table I is given for the characteristics of earthquakes occurred in the region from beginning of XVIII, century (4).

The information given about the seismicity of Turkey is dependable after 1935 that is the date of first official observation of the Kandilli Obervatory, established in 1910. There is also evidence that actual observations were made before that time by some religious men.

Depending on the catalogue of earthquakes in Turkey and her surroundings, earthquakes with magnitudes greater than 5 and estimated intensities greater than VI M.M. with epicentres in the area restricted by the coordinates 38° - 40°N and 28° - 30°E can be listed as follows on table I.

TABLE I

Earthquakes occurred in the Gediz region, with magnitudes greater than 5 and, estimated intensities greater than VI M.M. from 1700 until now.

Time	Intensity (M.M.)	Location of Epicentre	Magnitude
1700	VI	39.42°E 29.98°N	-
8. 2. 1826	VI	39.50°E 28.00°N	-
1859	VI	39.42°E 29.97°N	-
24. 9. 1866	VI	39.40°E 29.20°N	-
6. 10. 1886	VII	39.55°E 28.95°N	-
16. 4. 1896	VII	39.34°E 29.20°N	-
1911	VIII	38.50°E 29.50°N	-
1930	VI	39.34°E 29.25°N	-
3. 8. 1939	-	39.80°E 29.60°N	5.60
15. 9. 1939	VI	39.80°E 29.60°N	-
3. 7. 1941	VII	38.67°E 29.40°N	-
5. 2. 1942	VI	39.00°E 28.00°N	-
12. 8. 1942	VI	39.00°E 28.00°N	-
27. 10. 1942	VIII	39.20°E 28.20°N	-
15. 11. 1942	VII	39.80°E 29.60°N	-
25. 6. 1944	VII	38.90°E 28.30°N	-
5. 2. 1949	VII	39.80°E 29.60°N	-
10. 5. 1949	VI	38.54°E 28.65°N	-
3. 6. 1953	-	39.95°E 29.37°N	5.58
22. 7. 1953	-	39.10°E 28.50°N	5.25

We can notice that the Gediz region is shown in the second degree earthquake zone on the seismological map used in Turkey. On this map which is under revision Turkey is divided into four seismic zones (Figure 5):

- 1st degree zone is covering the part of country, close to the North Anatolian fault and to some of very active grabens of western Anatolia. The most violent earthquakes (intensity of IX. M.M. and more) can be expected on this zone.
- 2nd degree zone covers one part of neogenes regions of western Anatolia where Gediz and Emet are located. (The maximum estimated intensity on this region is VIII M.M.)
- 3rd degree zone covers the regions where only slight earthquakes may occur.
- 4th zone is the earthquake free zone where no seismic activity is expected.

After the revision of the map, the country will be divided into five zones and some of the region shown on the 2nd degree zone will be classified within the limits of the 1st degree zone.

4. SEISMOLOGICAL ASPECTS OF GEDIZ EARTHQUAKE

4.1 Time and Epicentre

The main shock occurred on 28th March, 1970 at 21.02.28.5 GMT according to the recordings of the Geophysical Institution of The Technical University of Istanbul (I.T.U.). The impressions of the local people led to estimate the duration of the first shock as 7 to 8 seconds with very violent and 30 more seconds with moderate quakes. First indicating shocks were registered at 20.07 GMT by Cine Observatory situated at 180 km south of Gediz. Local people also added that some slight shocks had begun around 19.30 GMT.

The epicentre is computed as 39.12°N - 29.50°E from the records obtained from Cine, Istanbul and Kastamonu stations. Also USCGS gave the epicentre as 39.182°N - 29.488°E where Strasbourg BCIS computed is as 39.1°N - 29.6°E. From the studies of the Earthquake Research Institute of The Ministry of Reconstruction and Resettlement, observing land deformations and the damage of the structures, the macroseismic epicentre is found as 39.1°N - 29.4°E.

A team of geologists of Turkish Ministry of Reconstruction and Resettlement and a group of I.T.U. Mining Engineering Faculty led by Dr. S. ABDUSSELAMOGLU fixed after a two week field survey, the epicentre at 7 km north-west of Gediz and 3 km north of the village, AKCAALAN. This location corresponds to a good average of computed locations by three stations mentioned above.

The depth of focus computed by USCGS is known as $h = 20$ km. It was, therefore, a rather shallow earthquake.

4.2 Magnitude and Approximate Amount of Released Energy:

Magnitude:

According to Richter, the magnitude, is determined by measuring the maximum amplitude of the recorded ground motion trace. The logarithm of this amplitude (A), corrected for the distance from the recording station by a subtracting factor, a factor dependent on the distance ($\mathrm{Log}A_0$), is the magnitude "M" of the earthquake.

$$M = \mathrm{Log}\ A - \mathrm{Log}A_0$$

The magnitude computed for the Gediz earthquake by some of the world stations are listed below, on Table II,

TABLE II

Strasbourg	: 7.75	Bensberg	: 7.60	Uppsala	: 7.40
Wien	: 7.10	Ksara	: 7.00	Rome	: 7.00 - 7.25
Lisbon	: 6.90	Moskow	: 7.00	USCGS	: 7.50

Using the value given by the dependable stations the average magnitude is computed as $M = 7.2$ (5).

Released Energy:

The relationship between the strain energy released and the magnitude of the earthquake is as known one of the significant aspects of the Richter magnitude scale. The total released energy E, varies logarithmically with the magnitude M, according to the formula: (6)

$$\mathrm{Log}E = 11.4 + 1.5M$$

For $M = 7.2$ of the Gediz earthquake, $E = 6.3 \times 10^{21}$ ergs.

A comparison of this value by the energy releases of some of the past earthquakes are listed below, on Table III.

TABLE III

Earthquake	Magnitude	Released Energy
San Francisco (1906)	8.20	5.00×10^{23} ergs
Tokyo (1923)	8.30	6.90×10^{23} ergs
Assam (1950)	8.60	2.00×10^{24} ergs
Gediz (1970)	7.20	6.30×10^{21} ergs

4.3 Intensity, Isoseismal Estimations and Acceleration Forces:

At present, the most extensively used intensity scales are as known M.M. (Modified Mercalli) and Rossi-Forel scales and also a revision of the M.M. scale which was adopted to local conditions in Russia by Medvedev.

Using M.M. scale a linear relationship between epicentre intensity and magnitude derived for the earthquakes of Turkey by Dr. Ipek is given as:

$$I_o = 1.689\ M - 2.75$$

For M = 7.2, I_o can be computed as $I_o = IX^{cr} - X$ M.M.

The field inspections made by the two teams of geologists mentioned above, let to admit that over a small uninhabited region of 6 - 7 km2 between Akcaalan and Yesilova the intensity IX was reached. The intensity VIII was reached over a region approximately 8 km wide extending from 2 km south of Gediz to a small town, Hisarcik located at 30 km North-west. The estimation of intensity IX is based on the observations of spectacular ground deformations such as vertical dislocations about 1.50 metres The intensity VIII is justified by the degree of damages that occurred on different types of constructions. For instance, the very few reinforced concrete structures, which are also properly constructed are affected only moderately so the intensity should not be greater than VIII in the town of Gediz.

Besides Gediz, the villages Akcaalan, Akkaya, Yesilova, Asik Pasa, Kayakoy, Caykoy, Soguksu, Igdis, Degirmen, Orenkoy, Derekoy, Catak, Halifeler, Yoncaagac, Hamam were also affected by intensity of VIII.

After a meeting between teams participating the field inspection on Gediz Region, held in Istanbul Technical University the map proposed by Dr. S. ABDUSSELAMOGLU was approved as the final isoseismical map of Gediz Earthquake, (Figure 6).

This map is not extended to Bursa region where the earthquake was felt quite violently and had caused heavy damages on the several recently constructed buildings at the "Fiat" automobile factory, located near Bursa and 130 kms north north-west of Gediz.

The degree of damages on the factory buildings at this location led to admit that the intensity level at Bursa was very close to the intensity of the epicentral region. (7)

The quite high intensity also at Arslanapa region, 50 kms north-east of Gediz makes the pattern of intensity distribution more unusual, (see Fig. 6).

All those observations suggest that much of the strain energy released during the earthquake moved outwards from its initial point at greater depths below the surface. Some of this energy should be sharply focused to the bedrock surfaces as that was the case in Bursa region. The components of motion with a long duration at the site of heavily damaged factory might also have been amplified because of the presence of deep soft soil conditions with a high ground water table.

The fact that, the quake effect was felt at distances of 600 kms and mdre, might be also due to the spreading of energy release deep in the ground. It should, further, be added that since no strong motion accelorograms were obtained, all these statements are based on ground motion phenomena.

Seismic acceleration is used to be expressed in terms of epicentral intensity (I_0). According to Richter's classical approximate formula:

$$\text{Log } a = 0.333 I_0 - 0.50$$

For $I_0 = 9$, "a" can be evaluated as 295 gal., for $I_0 = 8$ a = 150 gal., and for $I_0 = 8.5$ a = 200 gal.

Though the above values of "a" are approximate as obtained from this formula, they will still be used in this text, later on comparison basis.

4.4 Land Deformations, Fault Length, Area of Quaked Region:

At the epicentral region, geomorphological deformations were quite interesting. Fault dislocations were 0.50 metres horizontally and 1.50 metres vertically. This dislocation line could be followed with a number of discontinuities over 50 kms from 10 kms south-east of Gediz to 5 kms north of Hisarcik through Yesilova, Orenkoy. The big openings and the large dislocations were easily noticed to the north of epicenter, between epicentral zone and Derekoy region, over 15 kms the fault traced a regular continuous line. The fault line that traversed 12 kms south-east of epicentre, through the small village Erdogmus had caused some of the timber framed and adobe masonry dwellings to dislocate. The vertical displacement was measured as 1.35 m(4.5 ft) on a timber framed three-storey house.

On the sides of Gediz River Valley, local land cracks were formed and landslides occurred. Most of the important landslides were observed on a regular line of approximately 6 kms long, starting from a location at 5 kms north-east of Akcaalan, on the west side of Gediz River Valley and running in north-west south-east direction. The landslides were accompanied by the formation of grabens in most of the landslide areas.

About 1,000,000 km3 of land were displaced around Igdis and even the Gediz-Emet State Road was closed to traffic for three days. The fall of some rock pieces also occurred from the peaks of Gediz Rock Mountains. The groundwater table in the quaked zones did not change appreciably. No change was observed in the quality and quantity of spring waters. The water was reported to be more abundant in the public bath of Hamamkoy. Only soil liquefaction was noticed around the reinforced concrete bridge on Gediz-Emet road at 15 kms from Gediz.

An extensive observation on the dislocation lines let the geologists state that the earth portion between two parallel cracks was displaced downwards at some regions more than 1.0 metre though at most of the places on the line there was no visible opening due to the tensile forces, This makes one think that the motion of the existing fault line formed in the past was the geophysical origin of this earthquake.

From the magnitude of the earthquake the length of the formed fault can be found emprically by the classical formula of,

$$\log L = 1.32\,M - 7.99$$

For $M = 7.2$, the formula gives $L = 32.2$ km

The length of the formed fault was also estimated by yield observations, to be 50 km, as it was mentioned earlier.

The area on which the quake effect was felt can be found by the emprical formula given below:

$$\log A = 1.7\,M + 0.45$$

$M = 7.2$ gives $A = 500{,}000$ km2 (192,000 sq. miles) which seems unnatural for such a shallow earthquake, but the reality justified this result, to some extent, since the quaking effect was felt nearly all over the country even at very far distances from the epicentre. For instance, it was felt at towns located on the North Anatolian fault line which is 800 to 900 kms from Gediz.

4.5 Foreshocks and Aftershocks:

As after every destructive earthquake and sometimes before, the small fore and after shocks accompanied the main shock.

About one year before the Gediz earthquake, on 23rd March, 1969 at 21 08 41 GMT, in Demirci, and coincidentally exactly one year ago on 28th March, 1969 at 01 48 29 GMT, in Alasehir, destructive earthquakes occurred. The aftershocks of both earthquakes continued until the end of 1969. Plotting these aftershocks on map in Fig. 14 with white circles, a distribution in east-west direction is observed. (4)

Five days before the Gediz earthquake on 23rd March, 1970 at 08 57 GMT a foreshock was located 14 kilometers to the south of Gediz. This shock could be the aftershock of Demirci or Alasehir earthquakes.

After the main shock until 25th April, 1970, 1831 aftershocks were recorded by the Cine station. The epicentres of 150 of them are computed and plotted on the map in Fig. 14 as black circles. It is observed that the aftershocks of higher magnitudes are clustered around the epicentre of the main shock and others are distributed towards the west of the main shock. Some of these aftershocks were also recorded by some European stations and evaluated by BCIS. Aftershocks occurring between 28th March and 23rd April, with magnitudes 5 or larger are listed below, on Table IV.

TABLE IV

Aftershocks of the Gediz earthquake with magnitudes 5 or higher, recorded between 28th March - 23rd April, 1970

Date		Time	Epicentre	Magnitude	
March	28	23.43	39.0°N 29.7°E	5.0	Wien
"	29	6.56	39.0°N 29.6°E	5.4	Uppsala
"	30	7.59	39.3°N 29.3°E	5.5	"
"	30	16.32	39.2°N 29.8°E	5.3	"
April	7	17.05	39.2°N 29.2°E	5.5	"
"	16	10.42	39.0°N 29.8°E	5.5	"
"	19	13.29	39.0°N 29.7°E	6.0	"
"	19	13.47	39.0°N 29.7°E	6.1	"
"	22	5.24	39.1°N 29.6°E	5.0	Wien
"	23	9.01	39.3°N 28.7°E	5.7	Uppsala

Analysing the aftershocks during the period 29th March - 14th April, 1970 with respect to time, the frequency curve given in Fig. 15 is obtained. The total drop in this period is from 240 on 29th March to 36 on 14th April. The maximum points on the frequency curve indicate the increase in seismic activity after the shocks with large magnitudes. The maximum on 23rd April is the increase in activity after the shock having a magnitude of 6, which caused loss of lives and damage on 150 buildings in the town of Demirci.

5. DAMAGES AND STRUCTURAL ASPECTS OF THE GEDIZ EARTHQUAKE

5.1 Generalities:

Because of increasing interest shown to earthquake engineering problems of Turkey, the Gediz Earthquake was studied in detail by several groups of specialists as far as its structural aspect is also concerned. A special symposium was organised by T.S.C.E. (Turkish Society of Civil Engineers) to gather all information available of this earthquake. Besides the proceedings of the symposium some individual reports, in Turkish, covering mainly the structural aspect of the earthquake were published, too. (8) (9) (10). A report prepared for the Committee on Earthquake Inspection Division of Engineering of the American National Academy of Engineering, in English, is also available.(11)

In this study the emphasis is mainly given to the analysis of two reinforced concrete framed buildings. All other structural observations resumed so as to give at least a general idea on the structural aspect of the earthquake.

5.2 Summary of Loss of Life and Property:

The Gediz Earthquake caused a total loss of 1,086 lives on 28th March, 1970. On the following days, the aftershocks resulted the loss of 4 more lives. The total number of the injured people are not known exactly but it has been reported that 1,265 people were seriously injured.

The loss of life was revealed only in the province of Kutahya. In the nearby provinces only some injuries and the light damages of property were caused. On Table V, the distribution of the damages are summarised (12).

TABLE V

Loss of Life and Property Caused by The Gediz Earthquake of 28th March, 1970

PROVINCE	DISTRICT or VILLAGES	NUMBER of		NUMBER OF DAMAGED DWELLINGS		
		DEATHS	INJURED	HEAVY	MEDIUM	LIGHT
KUTAHYA	Gediz	360	275	2163	-	-
"	Gediz (Villages)	612	567	5592	755	-
"	Emet	-	-	317	-	-
"	Emet (Villages)	105	310	4505	2026	-
"	Simav	-	-	5	-	-
"	Simav (Villages)	2	5	915	114	-
"	Kutahya (Villages)	3	17	833	-	-
"	Altintas (Villages)	4	84	120	-	-
USAK	Usak Banaz Ulubey (Villages)	-	2	254	529	1302
MANISA	Selendi Gordes (Villages)	-	2	56	59	185
AFYON	Afyon Sandikli Sincanli Ihsaniye (Villages)	-	-	47	17	26
BURSA	Bursa (Districts) (Villages)	-	-	9	-	-
BALIKESIR	Dursunbey (4 villages)	-	-	36	46	46
OFFICIAL TOTAL (till April 6, 1970)		1086	1265	14,850	3546	1559
UNOFFICIAL ADDITIONAL TOTALS DUE TO AFTER-SHOCKS (MANISA: Demirci-Gordes, KUTAHYA: Gediz-Emet-Simav)		2	20	150	Uncounted	

The destructions of the Gediz Earthquake cover the buildings (dwellings, mosques, some administrative buildings, historical monuments, etc.). The bridges, viaducts, pipelines and other type of industrial structures were not affected by the hit.

The building art depends, as known, upon the local resources and prosperity of the region. At rural and unprosperous regions as Gediz area the types of the building can vary frequently from the engineered reinforced concrete buildings to the primitive timber framed houses.

The structural types in the Gediz region can be classified into three main groups:

(1) Timber Framed Structures:

(a) Rural type timber structures named as "himis" (irregular and poor jointed timber frames, filled for insulation by a heavy mixture of brick, stone pieces, and adobe. They are heavy and have poor damping quality).

(b) Urban type timber structures named as "bagdadi" (to the columns nailed beams and diagonals, and also wooden lathes on both inner and outer wall surfaces are connected, The space between the surfaces is filled with loose, light insulating material or is left empty. The surfaces are covered with plaster. The ductility and damping capacity is increased by the use of nails and the infillement downfall is prevented by lathes. This type of structure is a more refined form of "himis").

(2) Masonry Structures:

(a) Adobe masonry structures named as "kerpic" (used mostly in the middle east anatolian villages, the adobe is found in the Gediz region, too; though to a less extent. Regular wall shapes can be obtained by adobe and this is lighter than brick, but continuous timber lintel reinforcement at floor or roof levels, does not add much to the weak lateral resistance).

(b) Stone Masonry structures: (if they are well mortared, whatever the shape of the stone is, the regular walls and infillements can be obtained, but this is a heavy, brittle type of structure and its lateral resistance is not sufficient).

(c) Brick Masonry structures (used in both rural and urban areas. Brick is preferred because it is a material which can easily be handled and also because of economical reasons. This type of structure is lighter than stone masonry and if properly made using high cement mortar and tied by lintels it can have some lateral resistance, but, the material is expected, at any case, to behave in a brittle way).

(d) Mixed masonry structures (the slabs of most masonry buildings are of reinforced concrete and they rest on surrounding lintels. But, in Turkey, reinforced concrete columns also are used sometimes to tie vertically the masonry frame at the corners. The lateral resistance may look as if increased but the two materials, concrete and brick, of different characters are surely and easily disunited so as to cause a higher degree of hazard. The completely destroyed building was a mixed masonry structure. On the same picture the nearby buildings, some of reinforced concrete and others of brick masonry were not damaged at all).

(3) Reinforced Concrete Framed Buildings:

Despite the workmanship of rather poor quality and bad engineering, the reinforced concrete structures seem to be the best type of earthquake resistant structure in this region).

In the quaked region, the structures of type 1(a) and 2(a) constitutes the main type of the rural dwellings. The region being not industrialised, 78% of the population lives in the villages, according to 1965 census. Then, these types of structures (especially the timber framed ones) can be considered as the characteristic types for the Gediz region. In the towns and in some big villages, other types of structures mainly the brick masonry structures are more frequently met.

The number of destructed buildings was very high as seen on Table V. The percentage of hazard was in the order of 100% in the villages around the epicentre. The fire that started at night (28th - 29th March) in Akcaalan and in Gediz resulted the increase of the damage.

The sort of damage on each individual type of structure could not be evaluated separately over the whole region, but, an evaluation was made for Gediz town, itself, by H. AKTAN and A. TABBAN from Ministry of Reconstruction and Resettlement to whom we owe the interesting information summarised on Table VI.(13)

5.3 Details of the Behaviour of the Structures

5.3.1 Timber Framed Structures

(A) "Himis" type of Structures:

According to the data on Table VI, 70% of the structures in Gediz town, out of a total of 1,673, were of "himis" type. 46% of them completely collapsed or damaged beyond repair. 4.5% only survived the earthquake hit, without any noticeable hazard. In the villages, however, the percentage of this type is reported to be higher in number as well as the heavy damage.

TABLE VI

The Distribution of the Structural Damage in the town of Gediz (caused by the 28th March, 1970 Earthquake)

TYPE of STRUCTURE	COLLAPSED or HEAVILY DAM.	REPAIRABLE (medium-light) DAM.	NOT DAM.	PERCENTAGES of		
				TOTAL	HEAVY DAM.	NOT DAM.
1(a) Timber Frame	537	582	52	1171	46%	4.5%
1(b) Timber Frame with Wooden Lathes	19	107	42	168	11.2%	25%
2 Adobe and Stone and Brick and Mixed Masonry	79	118	95	292	27.1%	32.5%
3 Reinforced Concrete	10	18	14	42	23.8%	33%
TOTAL	645	825	203	1673		

The heavy infilliments of brick, stone and adobe of the "himis" type structures usually failed to resist the earthquake hit because of the differences in deformation characteristics of two materials, the timber and the fill.

Structural strength of the timber framed buildings depends upon the lateral resisting members and the quality of the connection of these members. No rigid and strong joints were observed in most of the damaged structures of this type.

The base of the timber fill walls should be rested on properly constructed concrete or stone strips surrounding continuously the building. When the walls are not correctly braced at base, all kinds of displacement and deformation are to be expected.

The diagonal members are of great importance in increasing the lateral strength of timber fill structures. The lack of these elements in the frame parallel to the direction of vibration caused the hazards of spectacular inelastic deformations. Second modal deformations of considerable amount were observed on three structures.

(B) "Bagdadî" Type of Structures:

The behaviour of this type of structures compared with all other types except reinforced concrete framed buildings, was much better under earthquake motions.

According to the studies made in Gediz 10% of the structures (168 in number) were of "bagdadî" type. Out of these only 19 (11.3%) of them collapsed or were damaged beyond repair, 107 (64%) of them were considered to be repairable and 42 (25%) of them were undamaged.

The severely damaged "bagdadî" buildings were those ones with improper bracings at the base. Some of them followed the motions of more stiffer buildings (brick or stone masonry) adjacent to them and were damaged because of the downfall of heavy masonry elements at their proximity.

Examples of properly constructed "bagdadî" structures behaved in a more striking fashion. In Akcaalan almost the only lightly damaged buildings were the three houses seen in Fig. 35, the two exterior houses seen on the same picture were of "bagdadî" type and they apparently affected the "himis" house located in between them, so as to resist the earthquake forces. Another good example of such a behaviour is given in Fig. 36, where six houses with quite complex architectural details, in Gediz, which were not damaged at all are seen. The nearby masonry structures, on the other hand, were all damaged.

5.3.2 Masonry Structures:

(a) Adobe and Stone Masonry Structures:

Though the adobe masonry structures do not have any lateral resistance, some of them resisted the earthquake forces. For example, on the adobe masonry three-storey house which was dislocated by the fault line in the village of Erdogmus no downfall of walls was observed. On the contrary, the two-storey farm house in Cavdarhisar at 30 km from the epicentre was destroyed as seen in

Fig. 37. The first floor of this house was of stone masonry with a very poor behaviour as can be noticed. The adobe has at least the advantage of having light weight, thus causing a less number of losses of life whereas the downfall of heavy stone walls is more hazardous, but it is also to be noted that the stone masonry when it is adequately made is much more resistant. Besides the quality of mortar (in preference cement mortar should be used) and of workmanship, the shape and the size of the stones used are of capital importance in the resistance of stone masonry buildings. The use of round stones decreases the bond between the stone elements and consequently decreases the lateral strength. The use of angular stones and arranging the corners of the stones one on top of the other, crosswise in length, results in the increase of resistance of structure.

(b) Brick and Mixed Masonry Structures:

Since the construction of these types of buildings are more and more frequently made in Turkish towns, emphasis was given to their study. The brick masonry buildings can resist sometimes the lateral effects in a proper way when they are combined adequately with high stone masonry basements and also when they are completely of brick and efficiently built, as seen in the case of Cavdarhisar administrative lodging.

The Turkish Earthquake Resistant Building Design Code fixed the ratio of the area of openings on the walls of a masonry building to the total vertical surface area as not more than 50%. The distances of openings from the corners should not be less than 1.50 meters, too. The disaccordances to these restrictions were the causes of severe damages in most of the cases. The Local State Forest Administrative building was one of these cases, A masonry residential building of almost equal size immediately next to the Forest Administrative building, has been built in accordance with the code restrictions and it suffered no damage except the collapse of its chimney.

Concrete roofs or heavy timber roofs on weak masonry walls constitutes a very bad solution to earthquake resistant building problems, especially if the roofs do not rest on continuous surrounding concrete lintels.

A light infillement material which is sometimes used instead of brick is a hollow tile made of muddy light weighted concrete. The masonry made of this material has no higher lateral resistance than normal brick masonry.

The lime mortar is considered as one of the factors decreasing the resistance of the masonry structures. It is also reported the lime disintegrated during the collapse of walls spreads a heavy dust. The people uninjured during the collapse may even be killed, later, by suffocation of lime dust.

As far as the behaviour of brick masonry structures are concerned, the most discussed cases of the Gediz Earthquake area were the houses of Soguksu village. In this village at 6 kms of the epicentre in the north-west direction, a group of single storey, brick masonry dwellings of identical architectural design and similar materials were recently built under the supervision of the Ministry of Reconstruction and Resettlement. The construction of a number of the dwellings was not completed yet on the day of the earthquake. These masonry structures showed a rather wide range of damage variation. Some of them were destroyed. At their immediate vicinity some others suffered only light damages.

The results of strength tests on brick and mortar specimens taken from each dwelling did not give any hint to fix a correlation between the material quality and the distribution of the damages on the site. The slight differences observed on the shapes of the lintels could not be a structural explanation of the cause, Fig. 51. Finally as a result of the detailed studies made by a group of Ministry of Reconstruction it was concluded that the special local soil conditions were the main factors in the occurrance of this peculiar phenomenon (14) (15). The presence of soft layer found by "Sakai" penetration tests varied at depths of 1.50 to 3.00 metres from the rough and hardened surface thus causing this uneven hazard distribution.

The brick masonry structures partly supported by reinforced columns on lower floors behave sometimes in a more brittle way than the other masonry structures. The irregular stress concentrations at the column heads make the nearby masonry wall portions more susceptible to forces. For instance, the brick wall near to the first floor reinforced concrete column head, had resulted in the collapse of all upper floors of the building. As for the decomposition of two materials concrete and brick, this is almost unavoidable and the downfall of bricks is frequent.

In Gediz, several heavily damaged or completely destroyed buildings were observed as examples of what was explained in the previous paragraphs. One of the buildings behaved in a quite interesting manner. This was a building located in the Kumtas district of Gediz and had six reinforced concrete columns in each storey. There were one storey masonry houses on both sides which restrained the movement of the first floor. The second floor deformed excessively in the plane of the frames. This deformation resulted in the complete collapse of the structure in one of the aftershocks.

Another example of inelastic deformation was observed in a three-storey building. The first two storeys were built in the classical reinforced concrete way and the third floor as typical brick masonry.

A very special type of damage observed on brick masonry structures is the fourth storey of properly constructed masonry house which collapsed. This building was located between two reinforced concrete buildings. The modal characteristics being different, it seems that, in this case; the less stiff frame happened to take the shock effect generated by the stiffer frame vibrations (Hammering Effect). It is notable that, a small brick masonry house seen at its left had been probably hammered, by the stiffer three-storey house.

(c) Special Masonry Structures:

Most of mosques in the town of Gediz and its environment were damaged heavily or collapsed.

The Yesil Mosque of Kumtas district has been destroyed by the collapse of the reinforced concrete columns that were initially standing in front of the masonry wall supporting the rear part of the structure. One can note the lack of anchorage of the column on the footing. The mosque of Akcaalan, of reinforced concrete frame, despite the poor quality of material and construction suffered column cracks but did not collapse.

In the mosques it was observed that, the spherical reinforced concrete domes suffered no damage at all.

Of the ancient ruins in the Cavdarhisar vicinities, the exterior columns of the Greek temple (Zeus Temple) which are of marble toppled during the earthquake whereas some other columns remained in place but suffered failures at base.

The behaviour of the masonry structures can be summarised in general, as not being desirable. In Gediz, though about 30% of such structures remained undamaged, some 27% were destroyed or heavily damaged. The downfall of heavy walls increases the number of loss of lives. Incidentally, a great number of deaths, in Gediz, were found in or very near to the damaged masonry houses.

5.3.3 Reinforced Concrete Structures:

In Gediz, 10 of existing 42 reinforced concrete structures were reported to be severely damaged, but none of them reached the stage of collapse except the textile workshop located on Gediz-Akcaalan road, that is very near to the epicentre. This was a single bay, gable framed structure and collapsed by slipping of columns in a spectacular way. No strong anchorage connections were observed at the base of the columns.

Another example of column slipping because of lack of anchorage was observed in one-storey Mobil gas station near Gediz. On the same building, in the opposite corner, the column head failed.

Two reinforced buildings on the east side of Gediz River were damaged because of excessive differential settlement of alluvial soil.

In Gediz, a three storey hotel building with a penthouse had typical compressive failure at the heads of the first storey columns. Since no collapse occurred, the provisory reparation of those columns had been tried by the owner. The repaired building survived the aftershocks.

In Gediz, on the northern part of Gediz River Valley, there were a group of one storey reinforced concrete carpentry shops. Although these structures were designed for three storeys, only one storey had been built and still the solumn failures occurred. This was due to an unforgivable structural concept mistake. The beam joining to the column in the failed zone is a very stiff lintel of window. At 60 cms above this lintel, there was the beam of the reinforced concrete frame. The column excessively stiffened by connections of two parallel girders, one close to the other, had experienced the whole lateral effect and had failed. The failure due to the same conceptual mistake was much more striking on the similar column of the next shop. The joint formed by lintel and column had been completely disconnected and the lintel had been disunited from the next column joint also.

Outside of Gediz, the damages on reinforced concrete framed structures were rather moderate; a garage at Hisarcik, two buildings annexe to the Kayakoy Hydro-powere Plant, etc. The exceptional cases were observed only in Bursa where as it was mentioned earlier, some factory buildings suffered very heavy damages and in Cavdarhisar, where a two storey motel building was severely hazarded.

A preliminary report on dynamic behaviour of the Cavdarhisar motel building and a similar analysis on the damaged Gediz hospital building had constituted the object of a communication presented to the Gediz Earthquake Symposium of the T.S.C.E. (16)

The author also presented the same study at its very, preliminary stage in E.C.E.E. session of Sofia, September, 1970. (17)

The analysis, in their complete form, will be treated in the next section, in detail.

6. SEISMIC ANALYSIS OF TWO REINFORCED CONCRETE FRAMED BUILDINGS

6.1 Gediz Hospital Building

6.1.1 Description of the Building:

(a) General Features:

The Gediz Hospital Building is located in the south-west part of Gediz Town, on the west of the Gediz River Valley. This is a typical reinforced concrete framed building based on a rectangular plan. The building was still on construction on the day of the earthquake. When it is finished it will be used as a hospital of 50 beds. The hospital was designed as a four-storey reinforced concrete building with a typical floor area of 720 m2 (52.22 m x 13.65 m). The first two storeys, constructed in 1969 and the third storey just finished before the earthquake, were built by two different contractors. The forms of the fourth storey were erected and the reinforcement was placed before the earthquake.

The total height of the building should be 14.00 metres finally, with individual storey heights of 3.50 metres.

All columns in the building are rectangular in cross-section except for a few circular columns of the second storey, located on the axis 10C and 15B. The larger dimensions of the columns are in the transverse direction, which is shown as the (y) direction on Fig. 7 of a typical floor plan.

The floor system of the building consists of a typical slab-girder system. The slab has an average thickness of 12 cm (4.75 inches).

All transverse girders are shallow rectangular beams having mostly a width of 23 cm (9.1 inches). Their depth varies from 60 cm to 70 cm (23.6 to 27.5 inches). Some of the first floor transverse girders have a width of 35 cm.

The logitudinal girders are T-beams on the interior axis and half T-beams on the exterior axis.

Four shear walls of 23 cm thickness are located on the axis 9 and 11 as shown in Fig. 7, but the walls are not constructed as monolithic elements. Large openings of 1.00 m wide are left in the walls at each floor level, probably to make the electric installations easier. Therefore, the walls cannot behave as real shear diaphragms but only act as short columns. No partition walls were built by the time of the earthquake on the second and third storeys, Only on the first floor some masonry partitions on exterior axis were seen. Because of their vertical and longitudinal discontinuity, those walls are considered as having no effect on the dynamic behaviour of the structure.

The foundation of the building was a combination of single footings and some strip foundations. Since no heavy loads are to be transmitted to the soil, the foundation was not a problem as far as the design and the construction are concerned.

(b) Design Criteria:

The Gediz Hospital Building was designed in 1968 under the supervision of the Design Control Services of the Ministry of Public Works. Design criteria was based on the "Reinforced Concrete Building Code" and on the "Allowable Load Values Code" and on the "Seismic Design Code" valid at that time in Turkey.

Working stress design method was used with the allowable stresses given on Table VII.

TABLE VII
(Allowable Design Stresses)

(1) Steel

$f_s = 1400$ kg/cm2 (~ 20,000 psi)

(2) Concrete

Compressive failure strength is 160 kg/cm2 (based on cube strength)

Column Compression (f'_c) col = 0.30 x 160 = 48 kg/cm2 (675 psi)

Flexural Compression f'_c = 60 kg/cm2 (858 psi)

Allowable Shear without stirrups v = 6 kg/cm2 (86 psi)

Maximum Shear with stirrups v = 16 kg/cm2 (228 psi)

For the final design of columns and for the check of girder supports under combined "vertical" and "earthquake + one half of maximum wind" load action, these stresses are increased 50%. (It can be noticed, however, that after the modification of the Turkish Seismic Code in 1968, only earthquake effect is combined with vertical loading effect, to increase allowable stresses by 50%. The combination of "vertical loads wind load" is studied separately for an increase of the allowable stresses by 33%).

The building was designed for dead, live, wind, and earthquake loads as specified in Turkish codes valid in 1968.

The floor live loads were calculated on the basis of 350 kg/m2 (71 psf), which is the usual intensity of load for hospital buildings. Only for stairways, live loads were taken as 500 kg/m2 (102 psf).

Horizontal wind loads in transverse direction were calculated using on the average a load of 100 kg/m2 (20.5 psf) as uniformly distributed over the whole vertical surface of the building.

Seismic effects were considered by assuming equivalent static horizontal forces existing in any single direction. These design forces are computed as "C" percent of the total dead load plus one half of the live load. According to the Turkish "Regulations for Constructions in Natural Disaster Areas" of 1963, C, the earthquake coefficient is computed as follows from the formula:

$$C = C_o . \alpha . B$$

where,

C_o is the earthquake zone coefficient,

α is the soil coefficient (taking the values 0.8, 1.0 and 1.2)

B is the building importance factor (1.0 or 1.5)

For this special building the following values should be considered:

$$C_o = 0.04$$

$$\alpha = 1.00$$

and

$$B = 1.50$$

Therefore, earthquake coefficient of equivalent horizontal force used for this building should be 6%. The designer approved using a factor of 6%, too.

After the modification of the code in 1968, a dynamic factor γ is introduced in the expression for C, is a factor to be computed in terms of the vibration period (T) of the building, and has the same meaning as dynamic vibration coefficient of some of the well-known seismic codes, for instance, the Californian Code.

For this building it could be obtained that $\gamma = 1.0$ and finally applying new regulations, equivalent earthquake factor would not be changed. The new code foresees a distribution of floor shear forces with a special trapezoidal distribution from top to bottom. Then, the shear forces acting on columns of each storey would be slightly changed.

The floor slabs were designed for vertical loads (dead + live) and it seems that they were assumed to act as single one way slab in (y) direction, between the axis (B) and (C). On the other hand between axis (A) and (B), and also (C) and (D) the slab portions act very likely as one-way continuous slabs in (x) direction.

The interior transverse girders which are located only in the spans AB and CD for most of the axis were designed as a part of one-bay frames (frame AB and frame CD). The exterior transverse girders form three-bay frames and were analysed as parts of these frames.

The longitudinal girders were assumed to act as multi-span continuous beams.

All columns were analysed and designed to resist the critical combination of vertical and lateral forces acting both in (x) and (y) directions. Prof. MUTO's lateral effect distribution method was used to compute the on each column or shear wall.

(c) Quality of Construction:

It is known that the reinforcing steel used for the construction was provided from Karabuk National Steel Plant. These were, therefore, commonly used plain bars, the so-called St-37 on market, their rupture strength being around 37 kg/mm2 (52,800 psi). No reinforcing specimens were taken from hospital building to check the steel quality, but Karabuk's St-37 steel is checked by several laboratory tests and is thus known by its stable mechanical properties. Its nominal yield stress is given as 24 kg/mm2 (34,200 psi) and at the laboratory tests the measured yield stress is always slightly larger than the nominal yield stress.

A poor quality of concrete is observed on the structure. The concrete surface is very rough because of too large aggregates and also there are big holes present in the concrete mass, as seen on Fig. 78. This is very likely due to the poor gradation, poor placing and mixing conditions. The compressive strength of concrete on beams and columns was measured by "Hammer Schmidt" and on first and second floors it was found out that the strength had slightly differed from 160 kg/cm2, but, in the zones around holes this strength was estimated as less than 100 kg/cm2.

As for the construction details, several incorrect details were inspected, mostly on the third floor, as seen in Fig. 79 and Fig. 80. Near the base of almost all the columns of the third storey no stirrups were observed, also, continuity in the reinforcement for some of the columns of the two adjacent storeys was not provided, The continuity did not exist between the third floor stairway and the supporting girder of second floor, either. Furthermore, in addition to the improper reinforcement connections, concrete did not cover the reinforcing bars. Even the steps of this stairway were swaying under the action of a normal 75 kg (175 pounds) man. The contractor claimed that this poor detailing would be later modified and reinforced.

6.1.2 Observed Damage:

Despite the poor quality of concrete and improper construction details mentioned above, the hospital building was not damaged to point of collapse.

On the first two storeys almost no significant damage was observed.

On the third floor more severe damages were observed. There was a torsion crack on the beam that supports the stairs from third to fourth (unfinished) floor. Another interesting crack was a shear crack on one of the third floor beams.

More significant damages were seen on columns. On the top and bottom parts of most columns, flexural cracks were observed. The concrete at beam-column connections had mostly a rough, irregular surface with holes, as it is mentioned earlier. These cracks were not very clear for such misdetailed columns, but on the columns correctly erected, the cracks were very obvious with their openings and developed lengths in the stressed sections. Six of these columns showed at sections near to head typical flexural effect in (x) direction, or in other words in the longitudinal direction. Since the columns are stiffer in transverse directions, the sections had the least strength in (x) direction. Some of the cracks were quite large. At the head of the columns A4 and D15, the concrete surface of the compressed zone had slightly started to crash. As a result of these observations, one may conclude that some of the columns were heavily subjected to combined action of "compression + flexure" both at top and at bottom and for some top sections the ultimate capacities were almost reached.

Another damage to be noticed, though not a structural one, was the downfall of the formworks of the fourth storey. The direction of fall was the longitudinal one, which justifies the estimated directions of lateral action on the basis of the crack pattern of the columns.

6.1.3 Approximate Evaluation of Lateral Forces to which the Building was Subjected:

This evaluation is based on the observations made on the building, which were resumed in previous sections. Since some of the sections at column heads had almost reached their ultimate capacity, the flexural effect on these sections can be analysed quantitatively.

The inelastic behaviour of the sections was apparently governed by the flexural effect and the failure was or would be a tension failure.

For the evaluation of the flexural effect, one may refer to the interaction diagram of "flexure and axial force".

From the typical (M-N) diagram, for the tension failure part, it is seen that as the normal force decreases the ultimate moment capacity of the section also decreases. Therefore, the column that will fail first under the effect of the lateral forces, assuming equal sections for all columns, is the one with the smallest normal force. Computations of the stiffness of the structure with respect to (x) and (y) directions, and observations on the building itself (the direction of the downfall of formworks and the crack pattern of damaged columns) indicated that under the earthquake forces the building vibrated in (x) direction. Therefore, an analysis of the columns with the smallest moment of inertia about y-y axis and which carry the least normal force is carried out first.

The weakest sections chosen all have the dimensions of 35 x 23 cm and contain 4Ø16 plain bars ($A = A' = 4.02$ cm2 = 0.62 sq. ins.). The plane interaction diagram for the most critical column sections observed are shown in Fig. 84 for $f'_c = 100$ 120, 140 kg/cm2. Steel quality being quite unvaried, as it was explained above, the yield stress was kept constant as $f_y =$ 2,400 kg/cm2.

Due to vertical loads (dead loads on structure) there exists some bending moment about the (x) axis (M_x vectorial). An additional moment, caused by the lateral forces, acts in the same direction. In the case of the hospital building, columns are members of a space frame and some bending moments are also present due to the vertical loads about the (x) axis. Thus, the analysis turns into a problem of columns under biaxial bending.

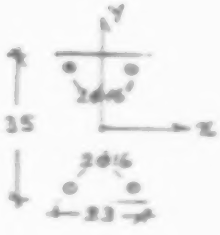
The problem of columns under biaxial bending and axial forces is studied in detail by Pannell, who derived the interaction diagrams for a symmetrically reinforced rectangular column first. (18) The most critical column sections of the hospital building are also symmetrically reinforced and rectangular. The space interaction diagrams are derived using the procedure given by Pannell. The projection of the interaction diagram for the most critical column sections on the moment plane is given in Fig. 85.

In analysing columns under biaxial bending it is usual practice to approximate the actual failure surface with an ellipse. For the hospital building, since M_x values are small compared to the ultimate moment capacity of the section, this approximation could not introduce significant errors.

The values of the bending moments acting on the most critical column heads due to the dead load on the structure are computed using the standard moment distribution method and given in Table VIII.

TABLE VIII

The bending moments and normal forces acting on the most critical column heads of the hospital building due to dead load.

Column	Section	N (Ton)	M_y (t-m)	M_x (t-m)
A2		3.57	0.01	-
A4		2.61	-	-
A15		4.32	-	0.79
A16		4.76	0.01	0.79
D4		4.79	-	0.69
D15		4.79	-	0.72

The necessary additional moment values arising from lateral loads to bring the sections to their ultimate capacity are given in Table IX.

TABLE IX

Moment values required to bring the column sections to their ultimate capacities

Column	N (Ton)	$M_{y_{ult}}$ (t-m)	M_{add} $M_{y_{ult}}-M_y$ (t-m)
A2	3.57	2.15	2.14
A4	2.61	2.05	2.05
A15	4.32	2.06	2.06
A16	4.76	2.13	2.12
D4	4.79	2.15	2.15
D15	4.79	2.12	2.12

From Table IX it is evident that the column section that will reach its ultimate capacity first is A4, since for that column the value of the required additional moment is the smallest.

As for the lateral force causing this moment, the following formula can be used: $P = M/ (1-y_o).L$, derived from the elastic behaviour of the structure, were y_o is defined as the ratio of the distance of the inflection point of the deflection curve from the bottom of the column to the total height of the column (L), which is found as 0.5 from tables prepared by Prof. Muto (19). The lateral force that will bring the column section A4 to its ultimate capacity is determined as 1.17 ton.

The force acting laterally on a floor level is distributed to the columns on that floor as known with respect to their relative stiffnesses. The stiffness of each column is computed by taking into consideration the stiffness of the beams joining to that column. Here, the force acting laterally on the floor level can be computed by reversing the above process. That is, multiplying the value of the lateral force acting on a single column, by the ratio of the sum of stiffnesses of all the columns on that floor to the stiffness of that column.

The stiffness of the uppermost floor of the hospital building in (x) direction is computed to be 10.768 dm^3 (I/L) and the stiffness of column A4 is 0.101 dm^3. The value of the force acting on the third floor which will cause the column A4 to reach its ultimate capacity is:

$$P = \frac{10.768}{0.101} \times 1.170 = 130.0 \text{ Tons}$$

Because of the two assumptions made at the beginning, this approach is qualified as "approximate". These assumptions based on the site inspections were: Vibration in the y direction (shorter direction of the building) is ignored; only one column reached its ultimate capacity in combined bending and axial load, the other columns remaining elastic.

6.1.4 Determination of the Lateral Earthquake Forces by Elastic Model Analysis:

If the structure is idealised as a shear type elastic model it is possible to compute the natural periods of vibrations and the model shapes of the structure. The masses are assumed to be concentrated at the floor levels and the building is assumed to perform shear deformations under the effect of lateral forces. This assumption would be true if the beams are relatively stiff compared to columns. The idealised shear type model of the multistorey frame is shown in Fig. 86(a), where m_i denotes the mass of the i^{th} floor, k_i, the stiffness of the i^{th} storey, determined by the value of the force acting laterally on the i^{th} floor level and producing unit lateral deformation within the i^{th} storey i-1.

The masses of the hospital building are computed by summing all the weight of the concrete members on a specific floor, using the spunit weight of reinforced concrete as 2.4 t/m3, including half of the weight of the columns and staircases adjacent to that floor and dividing the total value by the gravitational acceleration of 9.81 m/sec2. The weight of the forms and the reinforcement on the fourth floor is added to the weight of the third floor which makes this floor the heaviest one. In the ground floor there were stone infiliments, since none of these cover completely the space between the frame elements, their presence is ignored in computing the rigidity of the first floor.

The stiffness of a storey for a building with rigid floor beams is defined as:

$$K = \frac{12E\sum I/L}{L^2}$$

where L denotes the storey height and I, the moment of inertia of gross section. E is the dynamic modulus of elasticity which can be obtained from the below emprical formula:

$$E(kg/cm^2) = 16000\sqrt{f'_c}$$

f'_c is assumed as 100 kg/cm2 for the hospital building and E is computed as 1.6×10^5 kg/cm2.

In finding the rigidities of frames, the bending deformation of beams are taken into consideration. For this purpose, I/L ratios for the beams were needed to be known. The interior beams were assumed to be T-beams and the exterior ones as L-beams. The width of flanges, in both cases, were determined by the relations given in Turkish codes, with respect to the slab thicknesses adjacent to the beam. For the cases where the slab thickness is different on one side, the left and right width of the flanges were computed separately. For the cases where beams are missing, a part of the slab was assumed to be acting as a beam. In general reduction of column stiffnesses were on the order of 10% due to floor beam flexibility.

The idealized modified shear type elastic model of the hospital building for deflection in (x) direction is shown in Fig. 10(b).

The differential equation of free motion of a system, as known, is the following expression:

$$\left| [K] - \omega^2 [M] \right| = 0$$

where,

$[K]$ is known as the stiffness matrix, for the particular problem it is as:

$$\begin{bmatrix} k_1 + k_2 & - k_2 & 0 \\ -k_2 & k_2 + k_3 & -k_3 \\ 0 & - k_3 & k_3 \end{bmatrix}$$

$[M]$ is the mass matrix.

ω denotes the frequency of vibrating motion.

Substituting the values of k_i and m_i and writing the above equation in open form, the characteristic equation is obtained as follows:

$$\lambda^3 - 2.774 \times 10^3 \lambda^2 + 1.805 \times 10^6 \lambda - 0.163 \times 10^9 = 0$$

where,

$\lambda = \omega^2$

The solution of the last equation yields:

$\lambda_1 = 109.6$	$\omega_1 = 10.46$	rad/sec
$\lambda_2 = 821.0$	$\omega_2 = 28.66$	"
$\lambda_3 = 1853.0$	$\omega_3 = 42.92$	"

Assigning any one of the model amplitudes, a_i, values unity, relative model amplitudes of the mode shapes are determined for each of these specific λ_r values.

The natural periods of vibration are determined from the natural circular frequency values by the relationship: $T_r = 2\pi/\omega_r$. The mode shapes and natural periods of vibration are given in Fig. 86(b).

The lateral forces acting on floor levels (ith floor, motion of the rth mode) are computed from:

$$P_i^r = C(T_r) . m_i . a_i^r \frac{\sum m_i . a_i^r}{\sum m_i (a_i^r)^2}$$

where $C(T_r)$ is the acceleration spectrum factor and is a function of n (percent of critical damping) and N_e (the earthquake factor).

$\frac{m_i . a_i^r}{m_i (a_i^r)^2} = \mu_r$ is the equivalence coefficient.

The lateral earthquake forces acting on floor levels for the hospital building are determined in terms of $C(T_1)$ and are listed on Table X.

TABLE X

$P^1_1 = 10.77\ C(T_1)$

1st Mode $P^1_2 = 37.88\ C(T_1)$

$P^1_3 = 54.91\ C(T_1)$

$P^2_1 = 8.16\ C(T_2)$

2nd Mode $P^2_2 = 13.67\ C(T_2)$

$P^2_3 = -12.05\ C(T_2)$

$P^3_1 = 13.70\ C(T_3)$

3rd Mode $P^3_2 = -8.65\ C(T_3)$

$P^3_3 = 2.54\ C(T_3)$

It is known that the damping is not constant during vibration and reaches comparatively large values during cracking and inelastic actions. For the hospital building, since the transition region from elastic to elasto-plastic state was important, one can assume a constant value for the damping. It is assumed that, a single damping value may be assigned for the hospital building and is within the limits of 3-5% of critical damping.

Using these values of damping, the acceleration spectrum factors are determined for each mode shape from Housner's average acceleration spectrum. (20)

The values of $C(T_1)$ are:

(a) For $n = 0.03$

$C(.601) = 1.77\ N_e\ m/sec^2$ for the first mode

$C(.219) = 2.22\ N_e\ m/sec^2$ for the second mode

$C(.146) = 2.20\ N_e\ m/sec^2$ for the third mode

(b) For $n = 0.05$

$C(.601) = 1.47\ N_e\ m/sec^2$ for the first mode

$C(.219) = 1.77\ N_e\ m/sec^2$ for the second mode

$C(.146) = 1.75\ N_e\ m/sec^2$ for the third mode

The final values of the lateral shear forces are determined in terms of N_e by the formula:

$$F_i = F_i^1 + F_i^2 + F_i^3$$

which considers the most unfavourable condition. Then, for n = 0.03.

$F_1 = 40\ N_e$ ton, $F_2 = 70\ N_e$ ton, $F_3 = 100\ N_e$ ton

and for n = 0.05

$F_1 = 35\ N_e$ ton, $F_2 = 65\ N_e$ ton, $F_3 = 80\ N_e$ ton

It is noted that an increase in damping of 2% decreased the base shear by 18%. The parameters of the Gediz earthquake in determining the value of N_e are known as follows:

Magnitude (Richter) = 7.2
Duration = 7-8 seconds
Maximum earth acceleration:

as Computed in Chapter 4.3 is

$a = 0.295$ g for $I_o = 9$
$a = 0.200$ g for $I_o = 8.5$
$a = 0.150$ g for $I_o = 8$

Comparing these values with the values of other well known earthquakes it can be assumed that the value of N_e would be between 1.2 - 1.5 for the location of the hospital building in the Gediz earthquake.

The final maximum shear forces acting on the floor levels of the building for damping values between 3-5% critical damping and for N values between 1.2 - 1.5 are listed on table

TABLE XI

N_e=1.2	F_1 = 48 ton F_2 = 84 ton F_3 =120 ton	N = 1.5	F_1 = 60 ton F_2 =105 ton F_3 =150 ton
for n = 5%			
N_e = 1.2	F_1 = 42 ton F_2 = 78 ton F_3 = 96 ton	N = 1.5	F_1 = 53 ton F_2 = 98 ton F_3 =120 ton

The assumption made in arriving at these values are as mentioned:

(1) The acceleration spectrum of the ground motion at the location of the hospital agreed with Housner's average spectrum, multiplied by a factor of from 1.2 to 1.5.

(2) The building performed shear deformation under the earthquake forces.

6.1.5 Determination of the Earthquake Forces by the Turkish Regulation of 1968:

In the Chapter 8 "Rules of Design for Earthquake Resistant Buildings of the 1968 Turkish Regulation for Construction in Natural Disaster Area" base shear is given by the formula

$$P = C.W$$

mentioned above in Chapter 6.1.1

By the above formulation C was computed as 0.060. Using the values defined above, the base shear is computed as 71.0 tons. Distribution of the base shear on floor levels yields, 9.0 tons for the first floor, 23.0 tons for the second floor and 39.0 tons for the third floor, according to the 1968 Turkish Regulations tropezoidal shear distribution formula $P_i = P \frac{W_i.h_i}{\sum W_i.h_i}$

where P_i denotes lateral force at i^{th} floor P total lateral force of the building W_i weight of the i^{th} floor computed as $W_i = G_i + \frac{1}{2} P_i$ (G_i = Dead loads, P_i = Live loads $\frac{1}{2}$ = live load factor which is 1.0 for schools, theaters etc. and 0.5 for hospitals and all other buildings h_i heights of the ith floor from foundation level.

6.1.6 Evaluation of Natural Period by Periodometer Measurement:

A quite sensitive periodometer developed by A. Aytun, Deputy Director of Natural Disasters Research Institute of the Ministry of Reconstruction and Resettlement was used to measure the natural periods of the hospital building.

In longitudinal direction the resulting natural period was found as 0.640 sec. This value is quite close to the natural period of vibration of the first made computed as $T_1 = 0.601$ sec. (See Fig. 10(b)).

6.1.7 Discussion of the Findings:

The value of the total base shear may be approximated by using the value of the lateral force obtained by the ultimate strength analysis of the most critical column sections assuming that the shear force distribution derived by the elastic model analysis is valid (Fig. 11)

Knowing that, a force of 130 tons acts on the uppermost floor of the hospital building, the value of the base shear can be obtained by summing the relative values of the shear forces and multiplying with the value of the force, that is 130 tons.

Then, $F = 130\ (1.00 + 0.691 + 0.200) = 245\ t$

Assuming an average value of 245 tons for the base shear, the maximum acceleration the structure was subjected to during the earthquake, can be obtained by dividing the value of the base shear with the total weight of the structure, that is 1190 t.

Then, $C = 245/1190 = 0.21\ g$

The value of the maximum acceleration to which the structure was subjected is seen to be 1.4 times the maximum ground acceleration computed for the location of the hospital building, with $I_o = 8$.

In determining the value of the total shear by the ultimate strength analysis of the most critical column sections it was assumed that the failure of these sections had taken place by a static lateral load acting through the centre of rigidity of the storey. The magnitude of this load was just sufficient to cause the mentioned sections to reach their ultimate capacities. Thus, the reversal of the lateral dynamic loads (fatigue effect), duration of loading, vibration of the structure and other dynamic effects of the earthquake on the structure are being ignored. A further assumption is that no section of any other element of the structures has reached the plastic state during the earthquake.

The behaviour of structures under dynamic loading being different from their behaviour under static loading, the validity of the first assumption is questionable. However, this is a common assumption made in nearly all the earthquake design codes in the world. The only basis of verification of the second assumption is the visual inspection of the damaged structure after the earthquake. For the structure under investigation, there was observed no indication that other sections had reached their plastic capacities.

In the elastic model analysis it was assumed that the structure can be idealized as a shear type elastic model. Furthermore the following quantities necessary for the computations were assumed as:

(a) Housner's average spectum is valid for the region.
(b) Earthquake factor $N_e = 1.2 - 1.5$
(c) Damping factor $n = (0.03 - 0.05)\ n_{cr}$

Assumption (a) is not very realistic from the point of view that the Housner's average spectrum does not indicate the relation between the natural periods of vibration of the foundation and those of the structure. The average acceleration spectrum curve reaches the maximum value at a period of about 0.25 sec. which is close to the measured period of vibration of the foundation of the hospital building (0.20 sec.), computed from the data (seismic wave velocity S_v) obtained by conical penetration resistance tests using the relation $T = 4\ H/S_v$ (In this expression, H is the thickness of the soil cover, S_v is the seismic wave velocity and T is the natural period of vibration of the soil). The error introduced in finding the value of the base shear by this assumption would then be about 5 - 10%. As a result of the computations based on these assumptions the maximum probable value of the base shear acting on the structure during the earthquake is obtained. It should also be mentioned that the dynamic properties of the earthquake and the building are partly considered.

Comparing the values of the base shear obtained by the ultimate strength analysis of the most critical column section with that of the elastic model analysis, the maximum value obtained in the second method (i.e. for $n = 3\%\ n_{cr}$ and $N = 1.5$) deviates about 15% from the value obtained in the first method. Here, the first method will be used as a basis of verification, since the structure was in such a state that all the assumptions made for the approach can be considered to be valid. If it is assumed that the actual value of N is 1.4 then the damping value should be increased to 0.04 to yield equal values of the base shear, in using the two methods. The value of the base shear, obtained by the Turkish Lateral Force Requirements is found to be small compared with the value obtained from the ultimate strength analysis of the most critical column section. This is due to the fact that the code philosophy is based on the high duetily of the reinforced concrete structures. The magnitude of the ductility factor that can be achieved in a structure depends as known on the material, the structural complexity and configuration, the speed of loading, the temperature, the tendency of some material to fail with a brittle fracture, and some other minor factors including joint, connections shapes etc. Therefore, the ductility of the material used is not a direct indication of the ductility of the structure as a whole. The tests performed under blast loading for frames of ductile materials or combinations of ductile materials generally have ductility factors from a minimum of about 3 to a maximum of 8. It can be advanced that as a minimum criterion reinforced concrete structures for earthquake resistance must be designed, and constructed in such a manner that the ductility factor will not be higher than 4 up to beginning of any visible damage and even smaller to the point of beginning of any structural damage.

In reducing the elastic coefficients for elasto-plastic values period, and damping can be ignored and the ordinates of the elasto-plastic spectrum are obtained by dividing the ordinates of the elastic spectrum by a quantity $\sqrt{2u - 1}$, where u is the ductility factor. For $u = 4$ at the hospital building, the elasto-plastic seismic coefficient C is computed as 0.08 g. On the Table XII, the different computed values of (C) are listed.

TABLE XII

The value of the base acceleration obtained by the ultimate st. analysis of the most critical column section	The value of the base acceleration obtained by assuming a ductility factor u = 4 for the structure	The value given by the Turkish Lateral Force Requirements
0.21g	0.08g	0.06g

It can be concluded that the Turkish code needs to be reviewed, in order of including the effects of ductility, damping and rigidity of the structure. At present the code ignores damping phenomena and assumes a single ductility factor greater than 5 for all types of reinforced concrete structures. Further research for this purpose is suggested to be started, soon.

6.2 Cavdarhisar Motel Building:

6.2.1 Description of the Building

The motel building is in down town Cavdarhisar, small town at 30 km Northeast of Gediz. The earthquake was felt in Cavdarhisar quite violently and its intensity was estimated as VII after detailed side inspections.

The building is a three-storey r.c. framed structure with all exterior and interior partitions and infilled walls completed up to day of earthquake, but it was not furnished yet, if no earthquake had occurred, it would be in service around 15th April.

In plan, the building covered an area of 145 m2 (~1560 sq.ft) and showed a regular geometry total sketched in Fig.12. The height of the building is 6.35 m (~20.8 ft), the first floor height being 3.40 m (11.2 ft) and the second floor height 2.95 m (9.6 ft). The stairway tower heighted 9.30 m, placed between axis 1 and 2.

Same design criteria as for the Gediz Hospital were used in the design of the building.

The structural system was a typical slab girder floor system, the slab having a thickness of 10 cm (4 ins). The girders measured mostly 23 cm x 40 cm and the columns were the 23 cm x 23 cm square columns reinforced by 4 ∅ 14 plain bars.

The walls are 23 cm thick brick walls.

As for the material the plain bars of type St-37 mentioned earlier were used as reinforcing steel. The concrete was foreseen as the standard concrete with compressive cube strength of

160 kg/cm2. The quality of concrete was checked visually on some columns and beam. That was not looking like a properly made concrete, because of its irregular aggregate.

The finishing work was a proper one and no obvious construction misdetails were observed as it was the case in Gediz Hospital building.

6.2.2 Observed Damage:

During the earthquake most of partition walls were cracked diagonally as seen on the fronts completely and the plaster was down inside of the building.

More significant structural damages were observed on the column heads of the first and second floors.

The damages were revealed as typical tension failures under flexural compression effect. Only the failure at head of column looks like occurring under a complex combined effect of flexural compression and shear.

6.2.3 Evaluation of Seismic Forces

(a) Analysis Based on Ultimate Strength Behaviour

In obtaining the lateral seismic forces the steps taken in the analysis are the same as given in Chapter (6.1) used for the Gediz Hospital Building.

In this building the most critical column section is determined to be that of C3 on which the axial force is smallest. The moment at head of this column about Y axis due to dead load is computed to be zero and hence the interaction diagram (Fig. 13) is reduced to the two dimensional case for this column. The value of the lateral force on the floor level acting in the Y-direction is found as 13.2 ton for f'_c = 100 kg/cm2 and f_y = 2400 kg/cm2. As mentioned previously small variations in the compressive strength of concrete do not affect the interaction diagram in the tension failure zone. If the required lateral force is computed for f'_c = 140 kg/cm2 a value of 13.7 ton is obtained.

(b) Elastic Model Analysis

In elastic model analysis the computation of the column stiffnesses was not easy, since the frames were infilled with brick walls. This problem was discussed by Ipek and Muto. As a rough approximation the column stiffnesses are determined such that the stiffness is multiplied by 2 if there exists an infilled wall only on one side and multiplied by 4 if there exists infilled walls on both sides of the column.

No live load due to the furniture was acting on the building. This made easy the evaluation of vertical loads and the determination of bending moments and shears due to gravity loads in both direction. The weight of the 1st floor was computed as 111 t and that of second floor as 158 t, then much greater than the first case because of the weight of partitions and infillaments.

Thus, the concentrated masses and the stiffnesses yielded as given in Fig. 14. Starting from those values, the solution of characteristic dynamic equation was obtained as:

$$'\lambda_1 = 109{,}266 \qquad '\lambda_2 = 790{,}059$$

which led to the periods of vibration

$$T_1 = 0.601 \text{ sec} \quad \text{and} \quad T_{11} = 0.223 \text{ sec.}$$

In finding the lateral earthquake forces Housner's average spectrum is used and for the location of this building the value of the earthquake factor (N_e) is taken between 1.0 - 1.2, using the reasoning described in section 1.4 of Chapter 6. The damping of reinforced concrete infilled framed structure is known to be 5 - 6% of critical damping, but, after the cracking of the infilled walls during the earthquake, this value can increase considerations reaching sometimes 15% of the critical damping. (21) In the case of the Cavdarhisar motel building, the brick infilled walls were less ductile than the reinforced concrete frame elements. The cracking of the infilled walls took place apperentin before the failure of the most critical columns sections.

The lateral earthquake forces for various values of damping and earthquake factors are listed below:

$n = 0.05$

$N_e = 1.0$	$F_1 = 21.0$ ton	$F_2 = 20.0$ ton
$N_e = 1.2$	$F_1 = 25.0$ ton	$F_2 = 23.0$ ton

$n = 0.10$

$N_e = 1.0$	$F_1 = 14.0$ ton	$F_2 = 13.0$ ton
$N_e = 1.2$	$F_1 = 17.0$ ton	$F_2 = 16.0$ ton

$n = 0.15$

$N_e = 1.0$	$F_1 = 13.0$ ton	$F_2 = 12.5$ ton
$N_e = 1.2$	$F_1 = 16.0$ ton	$F_2 = 15.0$ ton

6.2.4 Discussion of the results

In computing the lateral forces, the centre of rigidity is assumed to coincide with the geometric centre of the building. Computing the centre of rigidity of the structure, the eccentricity is found as 0.48 m in x-direction.

The torsional moment acting on the second floor is determined using the value of the lateral force obtained from the ultimate strength analysis of the most critical column section $M_t = 13.7 \times 0.48 = 6.58$ t-m. Distributing this torsional moment value to the columns of the second floor with respect to their rigidities and distances from the centre of rigidity, the force acting on column C3 in the direction of the lateral force is computed as 0.08 ton. This force of 0.08 ton is only 6% of the lateral force that would bring the column section C3 to its ultimate capacity and can easily be ignored.

Comparing the value of the lateral force obtained by the ultimate strength analysis of the most critical column section with the value obtained by elastic model analysis for $n = 0.05$, the value obtained by elastic model analysis is higher than the value obtained by the former method, but, for damping values between 0.10-0.15 and for $N_e = 1.0$ the values obtained by both methods are seen to be very close to each other. One can conclude that, if the assumed value of the earthquake factor is correct (i.e. $N = 1.0$) the structure achieved a damping value of 10 - 15% n_{cr} at the point of the beginning of the structural damage. In other words, at the point that the column C3 reached its ultimate capacity.

Visual inspection of the building indicated that several columns of the first and the second storeys had reached their ultimate capacities during the earthquake. Therefore a plastic analysis is necessary in order to determine the actual value of the lateral force.

7. CONCLUSIONS AND SUGGESTIONS

7.1 Conclusions on the Seismological Characteristics of the Earthquake

The 28th March 1970, Gediz Earthquake has a quite high magnitude as 7.2 and yet generated no very high intensities. This statement let to suggest that the released strain energy travelled a lot laterally at great depth below earth surface. The severe damages observed in Bursa at 180 kms of the epicentre justify also this estimation.

Unfortunately no strong motion accelograms were obtained during the earthquake. Thus, the statement on the seismological aspect of the earthquake are mostly based on the estimations. This makes one to remember the need of expansion of a strong motion network in active seismic regions in the world.

7.2 Conclusions on the Behaviour of the Structures and Suggestions for Improving their Lateral Resistance

Several Structural Conclusions are to be obtained from the Gediz Earthquake. Combining this conclusion with the structural observations made on the recent Turkish Earthquakes (Varto 1966, Akyazi-Mudurnu 1967, Alasehir-Sarigol 1968) the following features seemed to be emphasised:

(1) Timber frame brick fill structures: Even with a good quality of material and workmanship the behaviour of this type does not appear to be satisfactory during the earthquake, since the failure of the infillments is unavoidable. The infillments does not increase the lateral resistance but increases the weight of the structure and consequently the lateral forces. By designing timber frame details and using a light material for infillments the performance of structures of this type can be improved.

(2) Timber frame wood lathe with plaster structures are apparently the best local type of earthquake resistant structure. On the other hand, their construction requires vast amounts of wood lathes and a large contribution of workmanship. In place of the wooden lathes it is suggested that initially stretched steel wires may be used.

(3) Adobe masonry: Adobe masonry type of construction, being very economical and simple is seen to be a widely accepted type of construction in the earthquake regions of Turkey. Even if constructed in accordance with the recommendations given in the code, behaviour of this type of construction to earthquake motions may not be satisfactory.

(4) Brick and stone masonry did not behave in a satisfactory manner either. It is difficult to build properly, earthquake resistant masonry houses on the rural regions, since too many parameters are involved: Planning, workmanship and quality of bricks and mortar are quite variable, and all are important for earthquake resistance. It can be advanced the opinion that despite its economical advantages the brick masonry construction must be avoided in the first degree earthquake regions. Masonry built with stone can be constructed if only the material is quarry stone and the mortar contains certain amounts of portland cement.

(5) Reinforced Concrete framed structures are revealed once more to be the best earthquake resistant type with condition of taking care of their structural design concept and of construction details.

The commonly observed detailing mistakes to decrease the lateral resistance, of the reinforced concrete constructions were revealed in the Gediz Earthquake once again, as:

(a) Lack of adequate and strong girder-column joints.

(b) Missing the details of anchorage of columns to footing or to next storey columns.

(c) Poor concrete quality which decreases, dangerously, the column strengths and in some extend the bond capacity between reinforcing bars and the concrete.

As for the structural concept, to build partly reinforced or mixed masonry structures does not look like a good solution. Nor the behaviour of typical concrete structures, neither that of pure masonry are obtained and heavy damages are unavoidable. In design, the plan torsion due to the excentricity between rigidity centre and the centre of gravity of the structure are to be taken into consideration. The check of structural resistance is to be made absolutely in both, main frame direction and longitudinal direction of the building.

7.3 Suggestions on The Code Improvement:

(1) The natural period formula given in the Turkish code is quite similar to the formula used by some other well known codes, this formula is:

$$T = 0.09 \cdot \frac{H}{\sqrt{B}}$$

where H denotes the height of the building and B width of building parallel to vibration direction.

This formula looked once more, as to be reviewed in accordance with the natural periods of vibration of reinforced concrete structures obtained from loading tests on actual buildings. For Gediz Hospital Building, the formula led to a value of 0.113 sec whereas in the analysis of section 6.1, it had been obtained 0.601 sec, and the measure of periods by a periodometer had given 0.640 sec.

Such parameter as number of bays and storeys etc. must be introduced in the formula.

(2) As some of other codes, the Turkish code assumes a single ductility factor for all types of reinforced concrete structures, and its value is quite high. On the other hand, the damping phenonmena is ignored in the code. The ductility notien should be reviewed in order of giving a higher safety to the buildings and the damping must be introduced in the code approach.

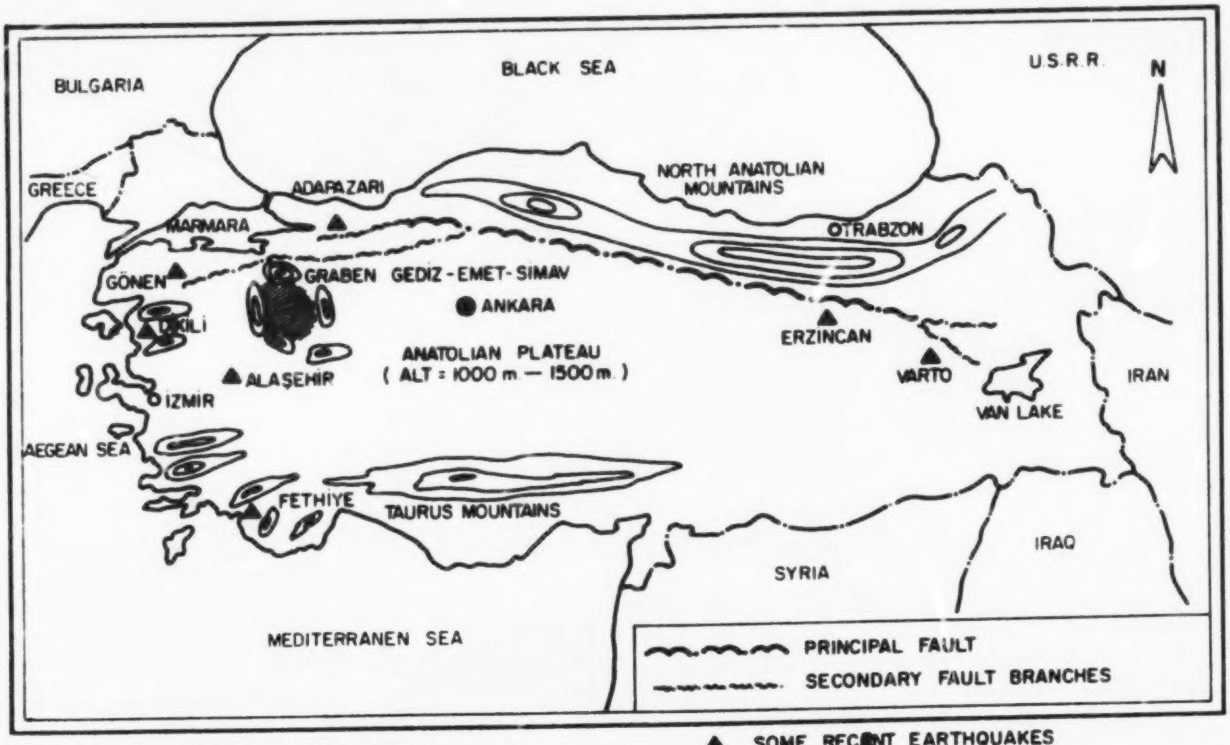
(3) Both observations and approximate analysis made on the masonry houses of Soguksu village and the factory buildings in Bursa indicate that the heavy damages in these locations may be attributed partly

to unfavourable combinations of soil conditions and building characteristics. The understanding of the influence of soil conditions on ground motions and building damages would lead to new, improved design requirements.

7.4 Post Emergency Problems:

To solve quickly the emergency problems in order to minimise the loss of life and the suffering of the citizens is a difficult task. The emational state of the people does not make easy the intervention of the authorities. Also blocked road conditions, damage to local medical facilities, make this task still more difficult. In Gediz it can be said that, emergency activities were realised quite well despite the landslides blocking the roads and the fallen debris filling the streets, making transportation very difficult.

The reconstruction of the damaged towns and villages started by May, 1970. In the meantime, the temporary housing problem had been solved by tents, most of the houses being used only for storage facilities. The Bayer Company of Germany provided a novel type of temporary structure of styrofoam and they have been used for temporary housing of Akcaalan people.


BLACK SEA
U.S.R.R.
N
BULGARIA
GREECE
ADAPAZARI
NORTH ANATOLIAN
MOUNTAINS
MARMARA
TRABZON
GÖNEN
GRABEN GEDIZ-EMET-SIMAV
ANKARA
DIKILI
ANATOLIAN PLATEAU
(ALT : 1000 m — 1500 m.)
ERZINCAN
VARTO
IRAN
ALAŞEHIR
IZMIR
VAN LAKE
AEGEAN SEA
FETHIYE
TAURUS MOUNTAINS
IRAQ
SYRIA
MEDITERRANEN SEA
PRINCIPAL FAULT
SECONDARY FAULT BRANCHES
▲ SOME RECENT EARTHQUAKES

MAP OF TURKEY (1 : 10.000.000)

FIGURE _ 1

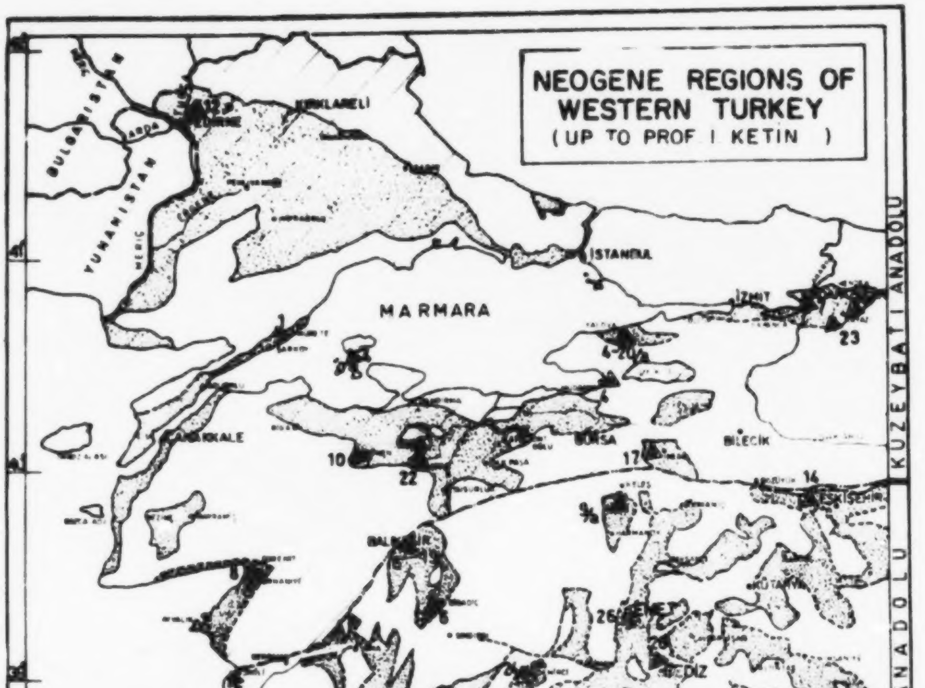
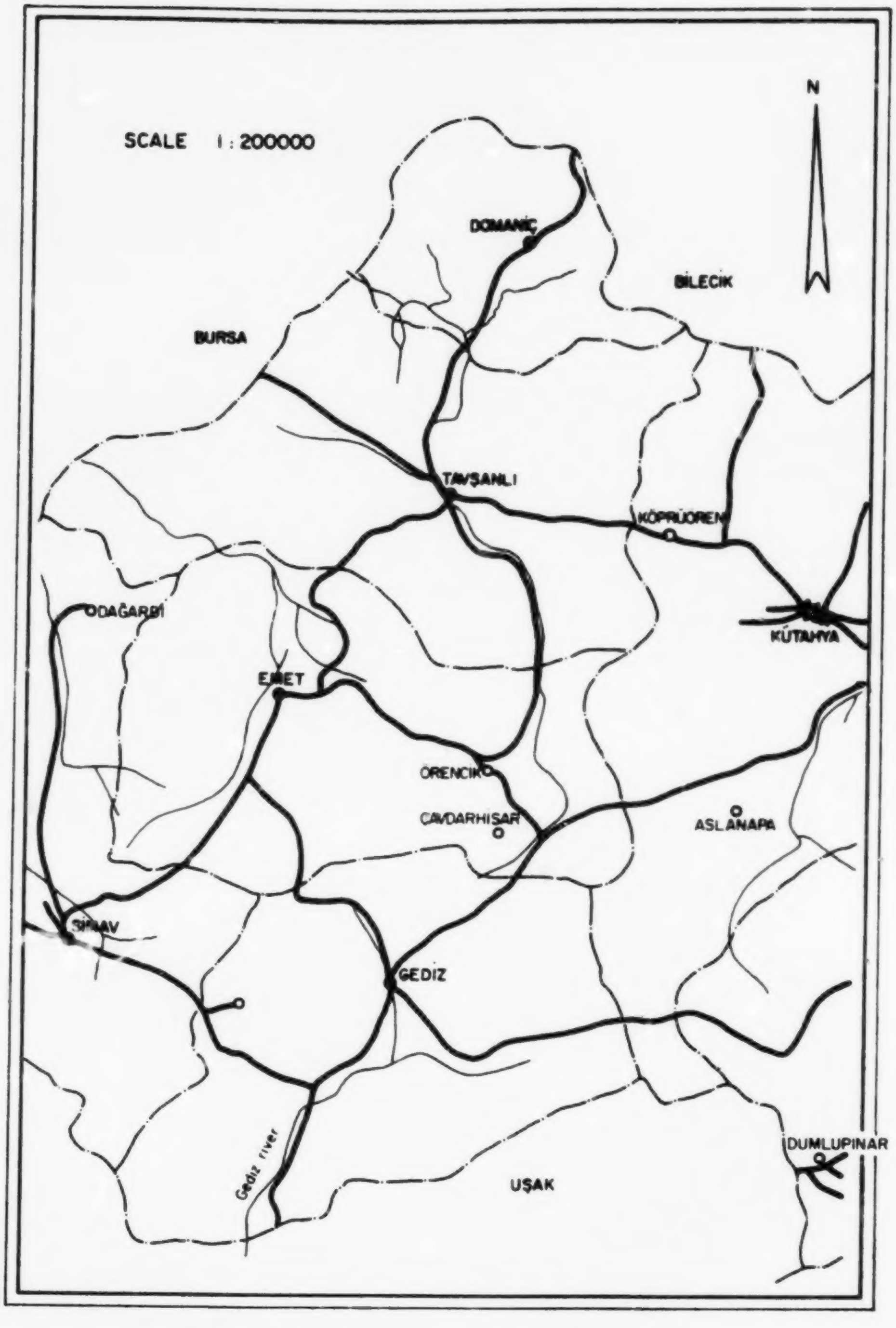

NEOGENE REGIONS OF WESTERN TURKEY
(UP TO PROF. I. KETIN)
BULGARISTAN
YUNANISTAN
MERIC
KIRKLARELI
MARMARA
ISTANBUL
İZMIT
23
4-20
BURSA
BILECIK
10
22
17
14
ESKISEHIR
BALIKESIR
KUTAHYA
26
GEDIZ
AFYON
USAK
11
5
9/b
3
B. MENDERES
25
20
2/a
BURDUR
ISPARTA
2
21
AYDIN
B. MENDERES
MUGLA
15-18
13
ANTALYA
KUZEYBATI ANADOLU
İÇ ANADOLU
BATI TOROSLAR
EARTKOUAKES WITH INTENSITY IV OR MORE SINCE 1912
NORMAL LIMITS
LIMITS ON FAULTS
NEOGENES
NW ANATOLIA
WESTERN TAURUS RANGES
0 20 50 100 Km
1-26 ORDER OF EARTKOUAKE OCCURRING
41
40
39
38
37
36
26
27
28
29
30

FIGURE _ 2


SCALE 1:200000
N
DOMANİÇ
BİLECİK
BURSA
TAVŞANLI
KÖPRÜÖREN
KÜTAHYA
DAĞARDI
EMET
ÖRENCİK
ÇAVDARHİSAR
ASLANAPA
SİMAV
GEDİZ
Gediz river
DUMLUPINAR
UŞAK

PROVINCE OF KUTAHYA AND ENVIRONMENT

FIGURE _ 3

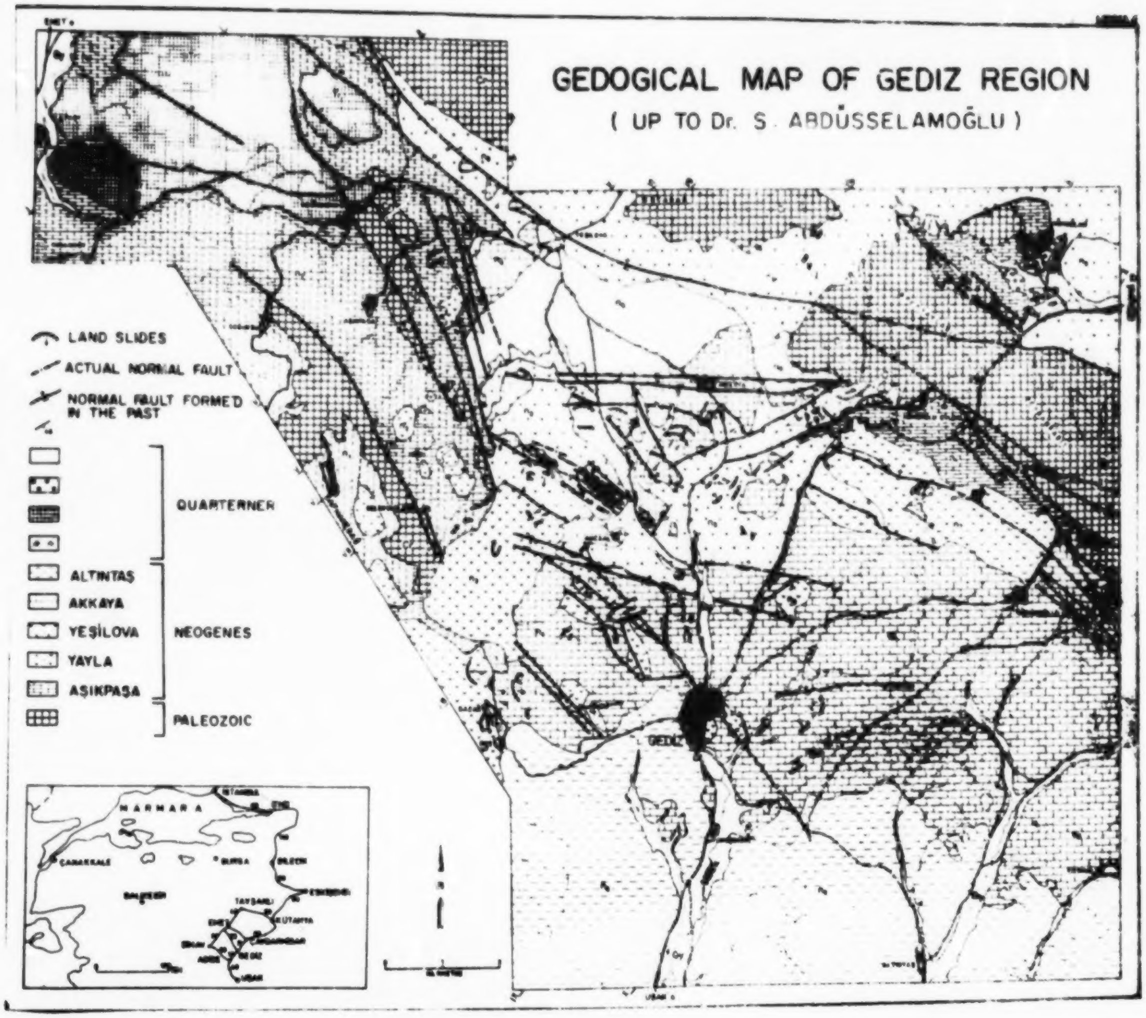

GEDOGICAL MAP OF GEDIZ REGION
(UP TO Dr. S. ABDÜSSELAMOĞLU)
LAND SLIDES
ACTUAL NORMAL FAULT
NORMAL FAULT FORMED IN THE PAST
QUARTERNER
ALTINTAŞ
AKKAYA
YEŞİLOVA
YAYLA
AŞIKPAŞA
NEOGENES
PALEOZOIC
GEDIZ
MARMARA

FIGURE _ 4

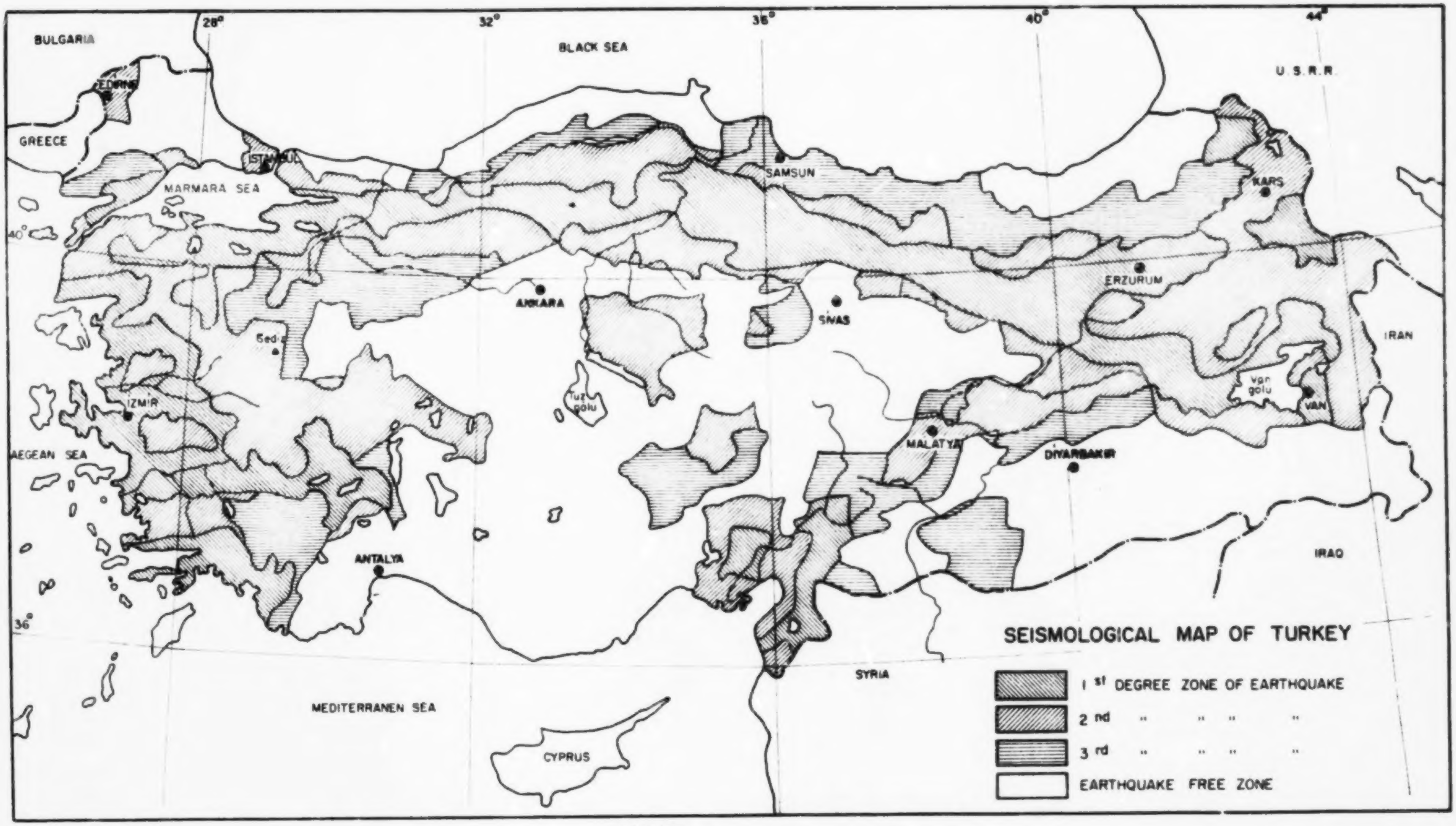

SEISMOLOGICAL MAP OF TURKEY
1 st DEGREE ZONE OF EARTHQUAKE
2 nd " " " "
3 rd " " " "
EARTHQUAKE FREE ZONE
BULGARIA
GREECE
BLACK SEA
U.S.R.R.
IRAN
IRAQ
SYRIA
MEDITERRANEN SEA
AEGEAN SEA
MARMARA SEA
CYPRUS
EDIRNE
ISTANBUL
SAMSUN
KARS
ERZURUM
ANKARA
SIVAS
IZMIR
Gediz
Tuz golu
Van golu
VAN
MALATYA
DIYARBAKIR
ANTALYA
28°
32°
36°
40°
44°
40°
36°

FIGURE 5

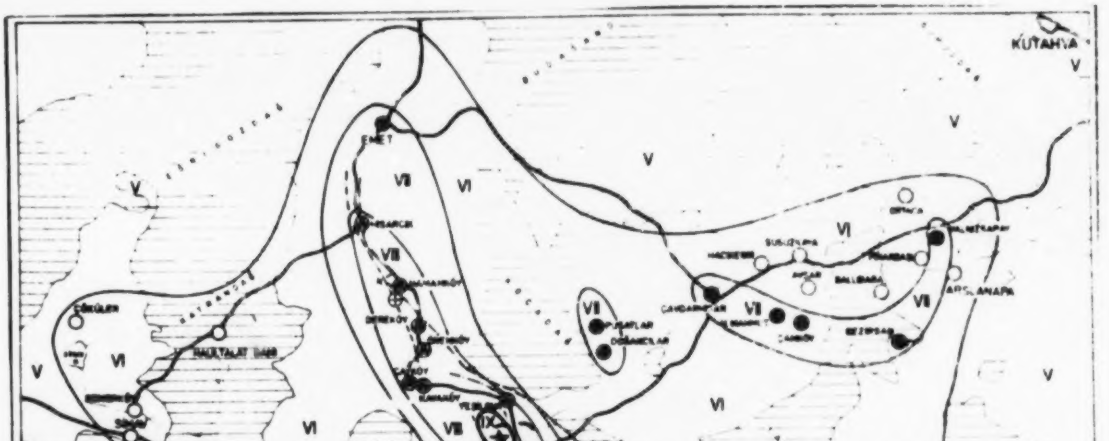

KUTAHYA
EMET
SAPHANE
GEDIZ
ALTINTAS
UŞAK
ISTANBUL
ÇANAKKALE
IZMIR
V
VI
VII
VIII
IX
ISOSEISMAL MAP OF GEDIZ EARTKQUAKE
(UP TO I KETIN, S ABDUSSELAMOĞLU, A AYDIN)
VERY HEAVILY DAMAGED
HEAVILY DAMAGED
SLIGHTL DAMAGED
HOT WATER SPRINGS
ISOSEISMAL CURVES
LAND SLIDES
ACTUAL FAULTS
NEOGENE AGED FAULTS
PALEZOIC AND MESOZOIC FORMATIONS
0
20
KILOMETRE

FIGURE 6

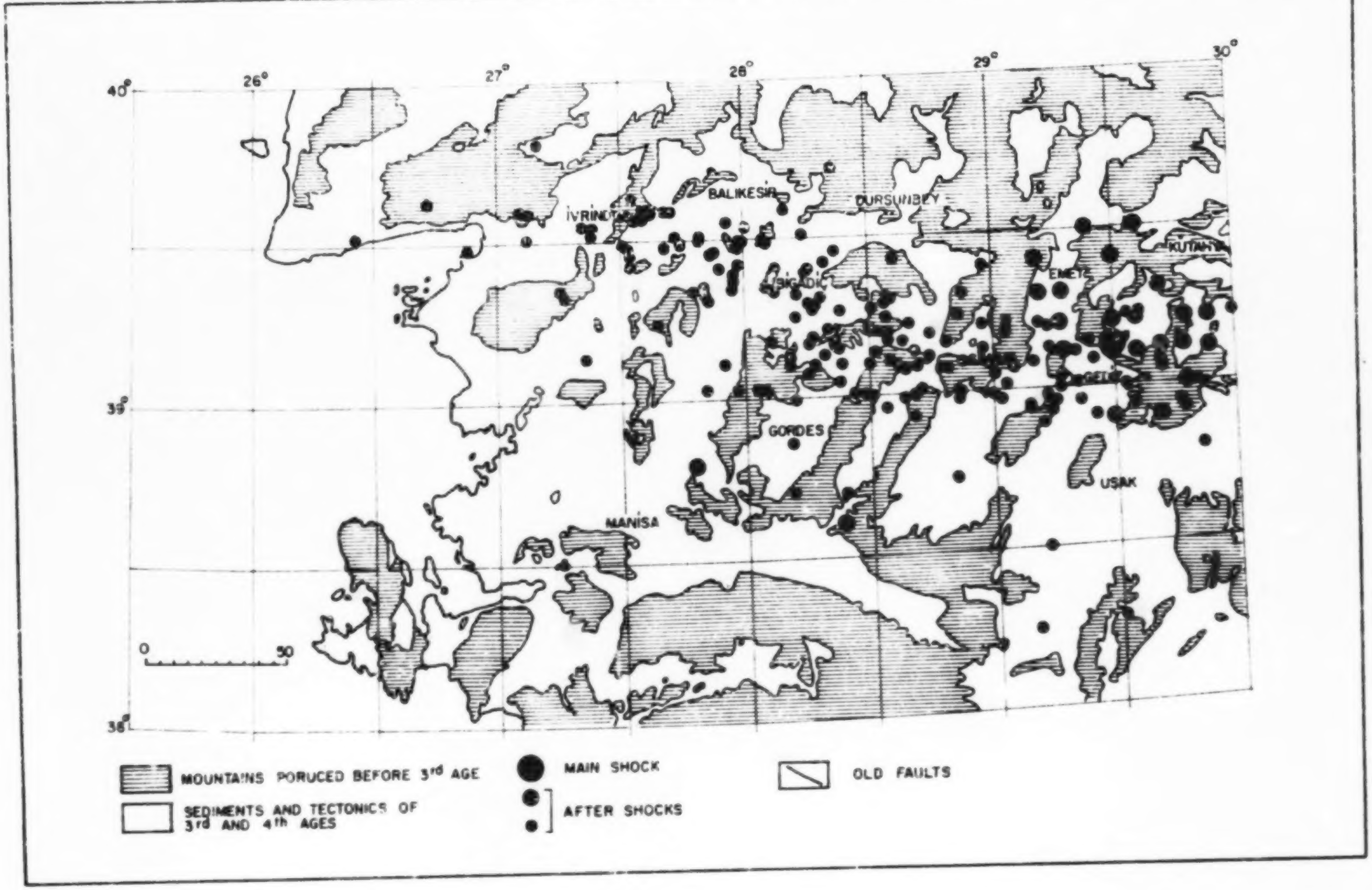
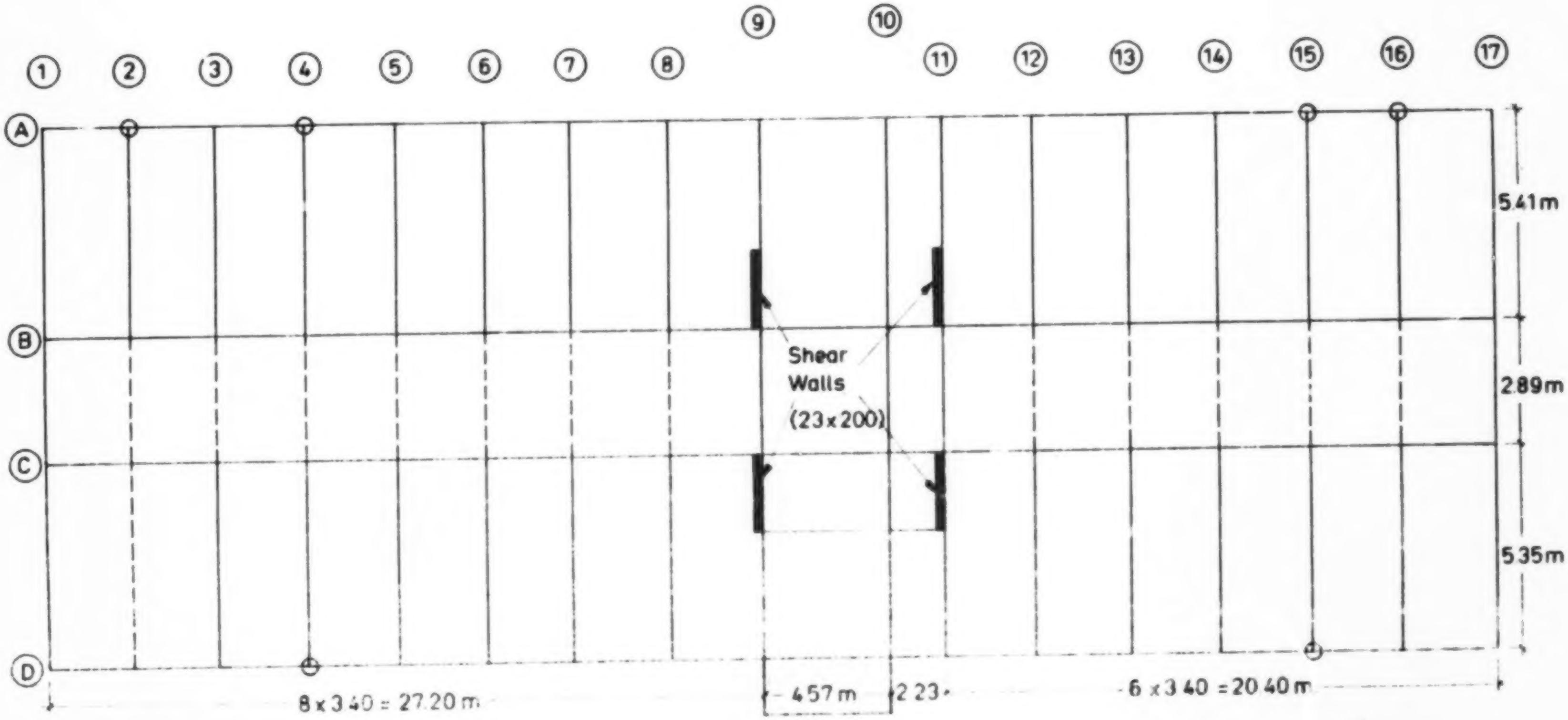

26°
27°
28°
29°
30°
40°
39°
38°
BALIKESIR
İVRINDI
BIGADIC
DURSUNBEY
EMET
KUTAHYA
GEDIZ
GORDES
USAK
MANISA
0
50
MOUNTAINS PORUCED BEFORE 3rd AGE
SEDIMENTS AND TECTONICS OF 3rd AND 4th AGES
MAIN SHOCK
AFTER SHOCKS
OLD FAULTS

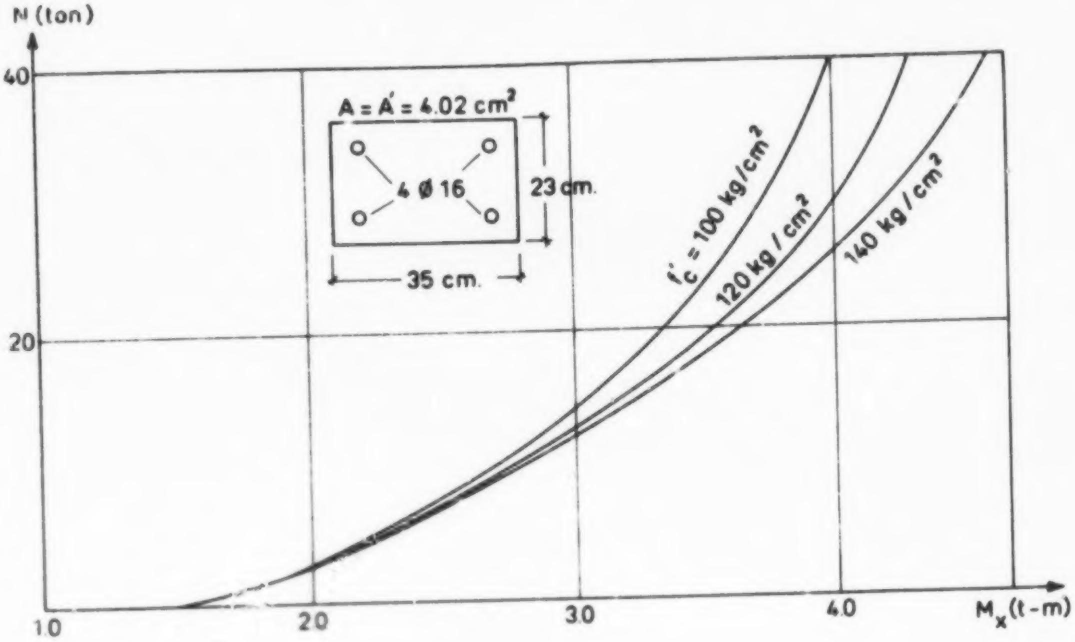
FIGURE _ 14


① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ ⑪ ⑫ ⑬ ⑭ ⑮ ⑯ ⑰
Ⓐ
Ⓑ
Ⓒ
Ⓓ
Shear Walls (23x200)
5.41m
2.89m
5.35m
8x3.40 = 27.20 m
4.57 m
2.23
6x3.40 = 20.40 m
y
x

Plan View of Typical Floors of Gediz Hospital Building

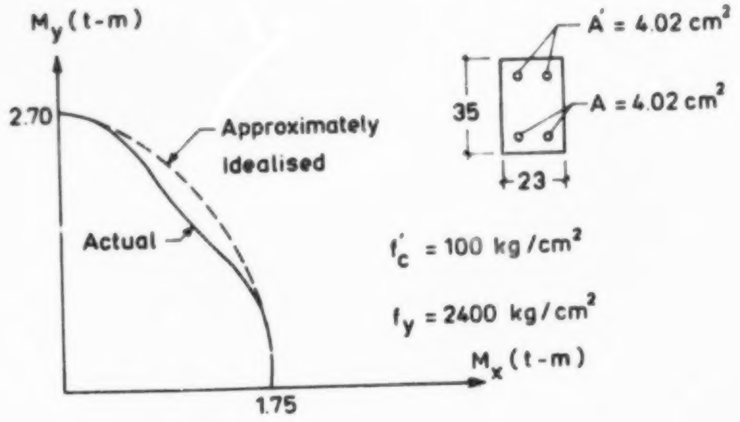
(○) Damaged columns at 3$^{\underline{rd}}$ floor

FIGURE 7



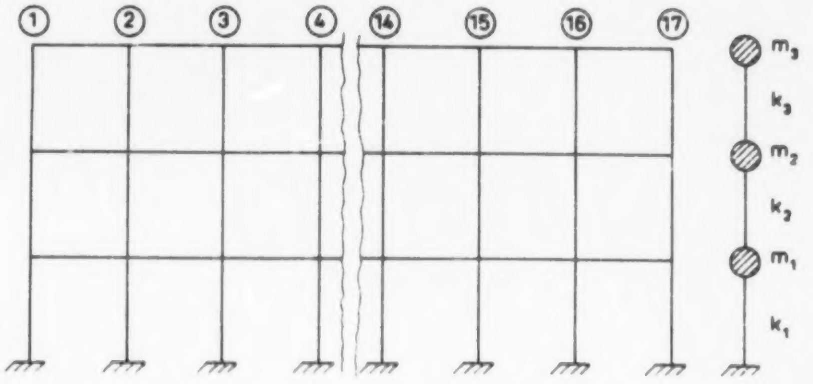
$[M_x - N]$ Interaction Diagrams

FIGURE 8



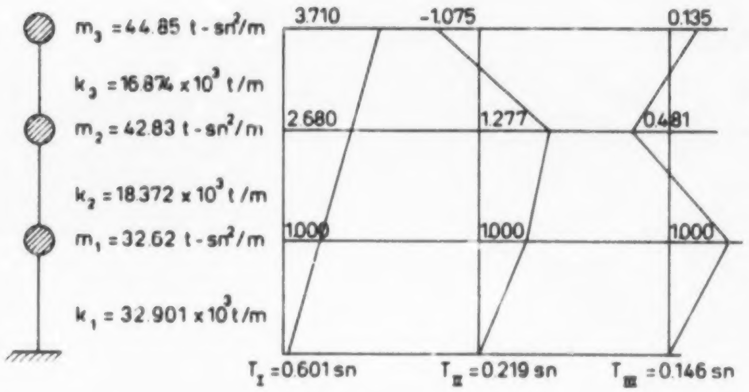
Projection of the Space Interaction Failure Surface for the Most Critical Column Sections

FIGURE 9


①
②
③
④
⑭
⑮
⑯
⑰
m_3
k_3
m_2
k_2
m_1
k_1

Idealized Shear Type Model of the Multi Storey Frame

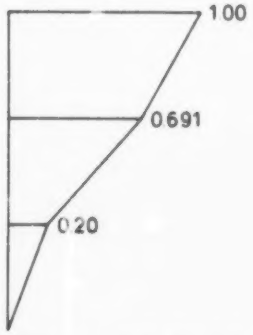
(a)


$m_3 = 44.85$ t-sn²/m
$k_3 = 16.874 \times 10^3$ t/m
$m_2 = 42.83$ t-sn²/m
$k_2 = 18.372 \times 10^3$ t/m
$m_1 = 32.62$ t-sn²/m
$k_1 = 32.901 \times 10^3$ t/m
3.710
-1.075
0.135
2.680
1.277
0.481
1.000
1.000
1.000
$T_I = 0.601$ sn
$T_{II} = 0.219$ sn
$T_{III} = 0.146$ sn

(b)

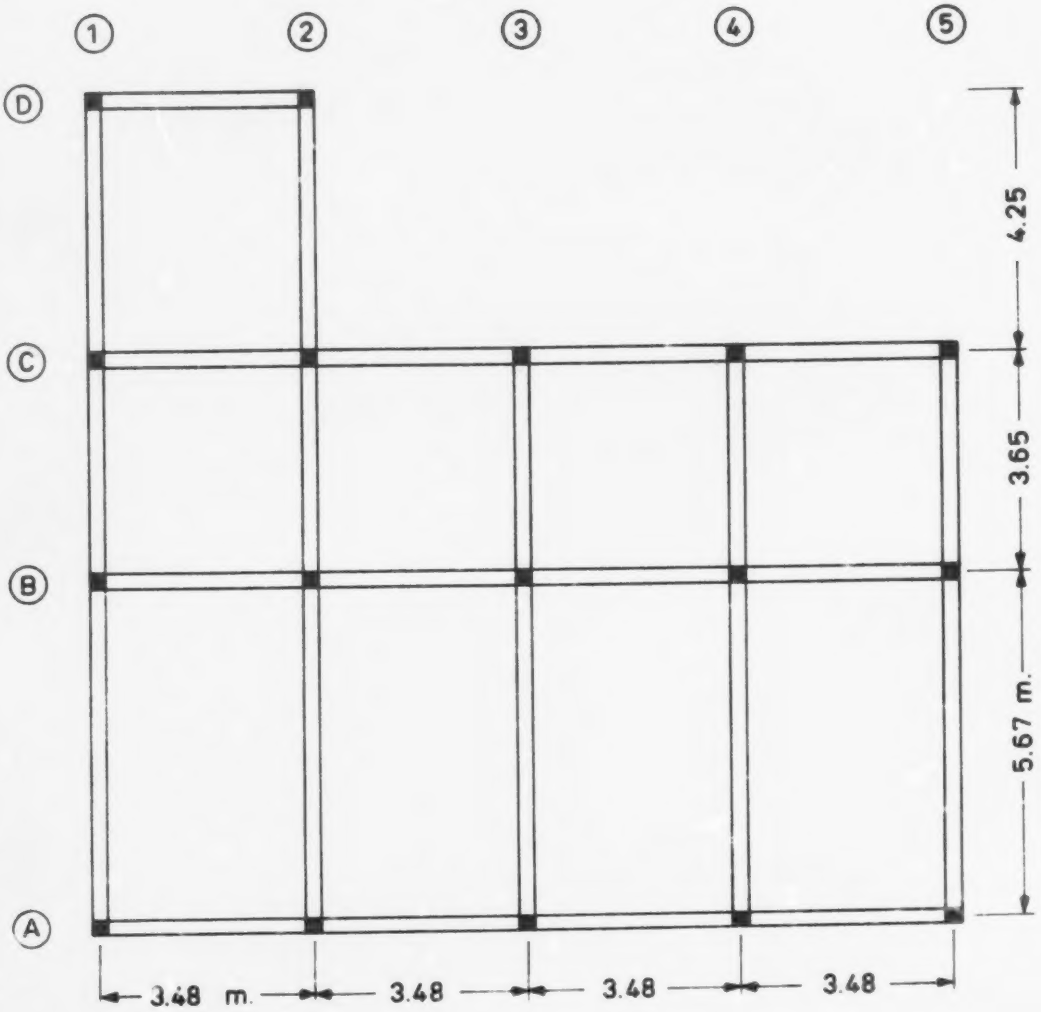
Gediz Hospital Building : Approximate Idealized System and Modal Caracteristics

FIGURE 10



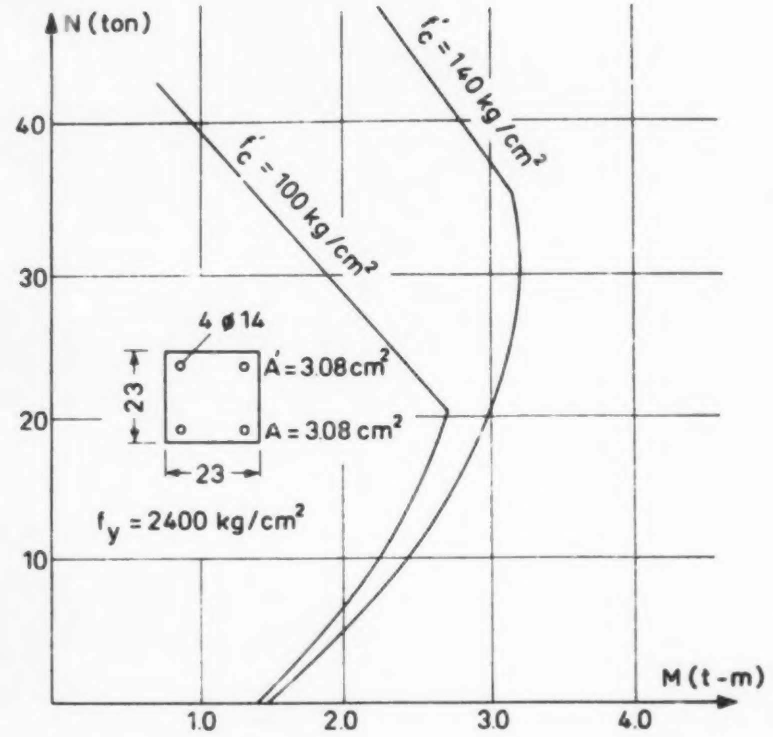
Gediz Hospital Building : Relative distribution of the lateral shear forces on the floor levels of for the fundemental mode of vibration.

FIGURE 11


1
2
3
4
5
D
C
B
A
4.25
3.65
5.67 m.
3.48 m.
3.48
3.48
3.48

Cavdarhisar Motel Building :
Typical Plan View

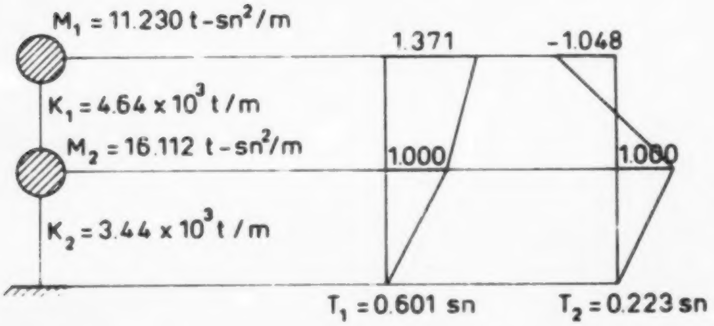
FIGURE 12



Çavdarhisar Motel Building:

(M-N) Interaction Diagrams for Column C 3

FIGURE 13


M1 = 11.230 t-sn²/m
K1 = 4.64 x 10³ t/m
M2 = 16.112 t-sn²/m
K2 = 3.44 x 10³ t/m
1.371
1.000
-1.048
1.000
T1 = 0.601 sn
T2 = 0.223 sn

Çavdarhisar Motel Building:

Approximate Idealized System and Modal Characteristics

FIGURE 14